SCIENCE

NEW SERIES
VOL. LXII, No. 1596

FRIDAY, JULY 31, 1925

ANNUAL SUBSCRIPTION, $6.00
SINGLE COPIES, 15 CTS.

SCIENCE

Vol. LXII JULY 31, 1925 No. 1596

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SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. McKeen Cattell and published every Friday by

THE SCIENCE PRESS

Lancaster, Pa. Garrison, N. Y.

New York City: Grand Central Terminal.

Annual Subscription, $6.00. Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the association may be secured from the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C.

Entered as second-class matter July 18, 1923, at the Post Office at Lancaster, Pa., under the Act of March 8, 1879.

THE SPECIFIC IMMUNITY OF THE TISSUES AND ITS BEARING ON TREATMENT[1]

AT the present time, in this day of rapidly increasing knowledge in all lines of human endeavor, we accept at first as wonders and then more or less as commonplaces the marvels that have been accomplished even during the past fifty years. We tacitly predict the future by the accomplishments of the past, and this has given us an almost unlimited optimism, even to a greater extent than previous generations have ever had. The various lines of study have been brought into closer contact with each other than ever before and have become interdependent.

The above applies equally as well to medical work as to other fields. Advances have been tremendous, and yet it seems that we have only begun to get into very close contact with what we do not know. Advances in surgery have not exceeded those in internal medicine, and the wonderful work done in the field of infection and immunity can be appreciated only by the trained student.

Advances in medicine have been made by improvement in existing theories and methods, and also by the introduction of new theories and methods. The latter has always been due to the utilization of previously existing knowledge, and could not have been possible without it. Modern scientific work abounds with instances of this, of which research in diabetes over the past forty years is a very good one. New ideas are readily tested by research work and the good separated from the worthless. This is putting the scientific imagination to its best use. Improvement in clinical results, even though slight, would be relatively considerable, as it would be in diseases that had previously offered special resistance to our efforts.

There is no more interesting or important subject in the whole field of medicine than that of infection and immunity. Cases of infection comprise most of those with which the practicing physician comes in contact. I mean by that the primary and secondary results of infection, whether they be specific diseases, infection of tissues by organisms that do not cause specific diseases or the general results of the absorption of bacterial toxines. By far the greatest part

[1] Address of the president of the Southwestern Division of the American Association for the Advancement of Science, Boulder, Colorado, June 8, 1925.

of human mortality is due to diseases that are caused by living organisms, and even in many cases that are not of such origin, the factor of infection must sooner or later be taken into account. This subject of infectious diseases constitutes our most important medical problem, and includes, of course, that of our natural and acquired immunity to them.

I will deal especially with the resistance of the tissues to the invasion of living organisms, which in clinical medical work are usually bacteria, but do not wish to be understood as minimizing the importance of the immune bodies that are present in the blood serum, either before infection takes place, or which develop as the result of our resistance to infection.

Every species of animal and plant has special preferences of habitat and food. These factors vary within extremely wide limits, in fact, to very nearly the same extent as living organisms do in structure and physiology. The same applies to bacteria, whether living outside of the body or in it.

The differences in the species of infecting organisms, the food required by each, the toxines formed and all the other factors concerned explain the wide variation in the human diseases caused by them. This constitutes the basis of human infectious diseases.

I will refer to bacteria as the infecting organisms, as they are the ones that most frequently cause human infectious diseases.

The problem presented by the growth of bacteria in the human body may be compared with the growth of a vegetable seed. The seed represents the infecting agent. It is well known that the seeds of different species grow with varying rapidity, that some are much hardier than others and also that different individual seeds of the same species do not have the same ability to grow, some producing small and others large and healthy plants. This corresponds with the virulence of the various infecting organisms, and the differences in individuals and strains. The seed can grow and reproduce only within definite limits of temperature, but can live above and below these limits. The gases with which it comes in contact are important, as are also the amount and character of the light. The water, and the chemicals dissolved in it, represent the body fluids, and the soil represents the tissues.

In agriculture one of the most important factors that is considered is the character of the soil. Does it contain the proper nutriment for the seed, are there present in it injurious chemicals and what is its biological content? The agriculturist wishes to know definitely about these points. The composition of the soil should be altered, when advisable and possible, to meet the varied requirements of the different seeds. Also, if the seed does not grow well, he wants to know why and always takes into consideration as a possible explanation the composition of the soil used.

In cases of human infection there must be good reasons why the bacteria do or do not grow on the tissues, that is, infect them. The changes in the tissues resulting from infection have been very carefully studied, but we have not given sufficient attention to the character of the tissues as far as it relates to their ability to resist infection. It is possible, and indeed probable, that this immunity of the tissues is the most important single factor in the institution of an infectious process.

The factors governing the growth of the seed in the ground and the bacteria in the human tissues are very complex. The total result in either case may depend upon only slight changes in any one factor. Bacteria in human infections must meet favorable conditions if they are to survive or grow actively on the tissues. Unfavorable conditions are quickly reflected in the results. This applies to variations in all the factors concerned.

Only a comparatively few of the organisms that get on or into the human body meet with sufficiently favorable conditions to grow on the tissues enough to injure them or produce a definite disease. Many bacteria and microscopic animal organisms enter the body, in one way or another, and are either killed quickly, die for lack of favorable conditions or are eliminated without growing on the tissues, but some may find a lodging and either do not injure them at all or so slightly as to be negligent. These are known as non-pathogenic organisms. However, others grow on account of meeting with conditions that are especially favorable to them; there is the kind of nourishment desired in the tissues affected and an absence of unfavorable chemicals in them and the fluids supplying them, or both. On the other hand, the tissues that are not affected either do not contain the food necessary for the infecting organisms or contain substances injurious to them which prevent or inhibit their growth, or both.

In the case of some diseases, like typhoid fever, the infecting organism gets into the general circulation and goes to all the tissues of the body, but only a few of these are infected, that is, permit the bacteria to multiply actively in them. Why are not all the tissues infected equally? The only possible explanation of this is that the tissues themselves in some, at present, unknown way resist invasion. This is a very important biological fact and is universal, as can be readily understood by a study of other infectious diseases. There are very important reasons for it which are not well understood, and the subject has received very little attention from bacteriologists and pathologists.

With regard to the influence of the blood serum, it may be said that the immune substances in it are too frequently not enough to prevent infection, but they develop sufficiently in time after infection has taken place to be a very important factor in killing the infecting agent. The composition of the serum is evidently not responsible for the resistance of certain tissues, and the inability of others to resist. The determining factor must be the chemical composition of the tissue itself.

After an injury to the tissues, whether it be mechanical, chemical or bacterial, the white blood cells exert a powerful protecting influence by collecting there in large numbers, but are not concerned in the incidence of infection of healthy tissues by bacteria.

As we may refer to the ability of certain organisms to grow on certain tissues as specific infection, so we may refer to the special ability of certain tissues to resist certain organisms as the specific immunity of the tissues.

Kolmer, in referring to the causes of this tissue immunity, states that "in general, we must conclude that either (1) microorganisms tend to be destroyed in every tissue or organ except those that are poor in defensive forces and are susceptible or (2) microorganisms or their products circulate passively through a tissue and do not lodge because they possess no affinity for these cells."[2]

The relative influence of the food supply needed by bacteria and the presence of chemicals poisonous to them could be determined by the addition of tissues to various bacterial cultures, using different media. A number of tissues have been used in the preparation of culture media, but they have been added for the purpose of encouraging the growth of bacteria and not to discover what power they have to prevent it.

If the cause of this immunity of the tissues were due equally to the lack of food supply and the presence of a poisonous substance, it would warrant the formulation of a natural law, as follows: *The human body contains preformed within itself a natural defense against, and a possible cure of, all infections to which it is liable.*

This infers that if the chemicals in the tissues that are poisonous to the infecting organisms could be isolated and made in sufficient quantities, they could be used not only in the treatment of these infections, but possibly also in prevention in special instances. This would be making use of one of the most important causes of our inherent resistance, which is certainly effectual and also probably the best that can be found.

The presence of these substances is only hypothetical, but the same may be said of numerous others commonly referred to in medical work and whose presence we do not doubt. I refer especially to the various immune chemicals present in the blood developing as the result of infection. The latter vary with the nature of the infection and the composition of the toxine produced by the infecting agent, and are entirely hypothetical. This subject, which we may term hypothetical chemistry, is a large and important one.

The vitamines will, no doubt, be isolated and identified before long. This will lead to their manufacture for therapeutic purposes. They are at present hypothetical, but we do not question either their presence or what they do.

The isolation of these protective chemicals present in the tissues will, of course, be a question of time and careful work, but should be as possible as the other successes of physiological chemists.

I will now review briefly the essential features of some infectious diseases that illustrate the points mentioned above. Hookworm infection is a good example. The life cycle of this parasite is as follows: Let us start with the worms adhering to the mucous membrane of the upper part of the human small intestine. The eggs are thrown off in large numbers and are discharged with the feces. They then develop only under favorable conditions of soil, moisture and heat, when they form motile larvæ. When these come into contact with human skin, generally on the hands or feet, they adhere to it, gradually work their way through it and enter the circulation. They are carried to the lungs, pass through the tissues, enter the air cells, pass up through the bronchioles, bronchi and trachea, and are then coughed up through the larynx. Most of them are probably then expectorated by the patient, but some are swallowed. On entering the stomach they are not killed by the gastric contents, but leave the stomach and attach themselves to the mucous membrane of the small intestine. They seem to know just what tissues in the human body to make use of in passage, and do not take up a permanent residence anywhere except in the small intestine. They do not attempt to go to any other tissues in the body, which they could no doubt do if they tried to, as other similar parasites do.

In trichiniasis the trichina spiralis is ingested in infected meat, and in the gastro-intestinal tract the larvae are set free from their enveloping sheaths, grow to maturity and produce numerous eggs, from which larvae develop. These pass through the intestinal mucosa and find their way to the muscles. Other tissues are not infected. The parasite seems to know instinctively where to go and how to get there.

The amoeba histolytica is also highly selective and finds its most suitable location for growth in the hu-

[2] Kolmer, "Infection, immunity and specific therapy," 1915.

man body in the mucous membrane of the colon and in the liver, and it occasionally, but seldom, infects the ileum. The path of infection is by mouth, the organism being usually ingested in the food and drink. It is not killed by the hydrochloric acid in the stomach, and does not attach itself to the oesophagus or stomach. Infection of the liver is through the portal circulation, and these organisms could easily get into the general circulation if they did not find the liver tissues especially favorable. The latest work seems to indicate that amoebae sometimes do enter the general circulation and infect other tissues, but this is unusual.

In typhoid fever the bacillus typhosus infects only certain tissues, the order of preference being about as follows: The lymphoid tissues of the intestinal mucosa, mesenteric lymphs glands, blood, spleen, liver and gall-bladder. The organisms are found in the circulation shortly after the time symptoms begin, and the isolation of them from the blood constitutes one of the methods of early diagnosis. Several tissues other than the above are occasionally involved, but the rest, constituting the great majority of all the tissues of the body, are not affected at all. This is clearly not due to the character of the blood serum, but must be due to the composition of the tissues themselves.

In diphtheria the Klebs-Löffler bacillus has special preferences of growth in the human body. It affects the pharynx, back of the nose, larynx and trachea. It will much less frequently grow in the bronchi and farther forward in the nose and mouth. The bacilli, of course, must be swallowed in large numbers, but the stomach and intestines are rarely involved. A number of cases of diphtheritic peritonitis have been reported, but they are rare, especially in view of the frequency of this disease. The rest of the tissues of the body are seldom infected.

The micrococcus lanceolatus, which causes lobar pneumonia, also has special preferences. The bases of the lungs are much more frequently involved than the apices. It has been found in pure culture in the pleura, pericardium, endocardium, meninges, joints and abscesses. It is frequently found in the sputum of tuberculosis patients in the absence of pneumonia, and may also be recovered from cultures made from the pharynx and back of the nose. Here also the bacteria are swallowed in large numbers and do not infect the stomach and intestines, but cases of pneumococcus peritonitis are occasionally reported. Other tissues are very rarely affected.

Tuberculosis is one of the best examples of specific infection and immunity that we have and is of universal interest to the residents of the southwest. It infects by preference the tissues of the body in about the following order: The apices of the lungs, bases of the lungs, pleurae, mediastinal glands, larynx, lymphoid tissues of the intestines and related lymphoid glands, peritoneum, urogenital organs, brain and the bones and serous surfaces connected with them. The tissue that is least often infected, in fact, that is practically never infected, is that of the muscles. The tubercle bacillus gets into the general circulation and goes to all parts of the body, after which time all the tissues have an equal opportunity to be infected, at least, as far as this factor is concerned. The protection against infection is evidently not in the blood serum, but is inherent in the character of the tissues themselves.

The therapeutic application of these principles is very broad, and if only partially successful should permit a great reduction in the mortality from diseases that are either incurable at present, or whose ravages are enormous.

It would not be necessary for a chemical that is given for therapeutic purposes to kill the infecting organism. All that would be needed, in many cases at least, would be to moderately reduce its vitality. In most cases of infection the difference between the ability of the organisms to infect and all the forces of the body to resist must be rather small; otherwise these cases would not only be fatal, but rapidly so, especially in the acute infectious diseases. The more acute and fatal the infectious disease the larger will be this margin of infectivity, as it may be called, while it is proportionately less in the milder and more chronic diseases. In the instance of such a chronic disease as tuberculosis this margin of infectivity must be very small, owing to the long duration of the disease and its slow clinical course.

The composition of the tissues of the various animals used in research and for making biological preparations is not exactly the same as that of the human tissues, but corresponds closely enough for therapeutic purposes, as is proved by the variety and importance of the preparations that are already in use. The field from which to choose is almost unlimited.

Some animals are not susceptible, and others only slightly so, to the organisms causing many human infections. It is possible that this species immunity may be made use of, in fact, it should be of considerable practical advantage.

We may use tuberculosis to illustrate the therapeutic aspect of this problem. The muscles are not infected in spite of the facts that the tubercle bacilli get into the general circulation and that the resistance of the patient in most chronic pulmonary cases is at a low ebb for a considerable time before death. The patients frequently become exhausted and emaciated to the last degree. The muscles are greatly atrophied,

and would certainly contain tubercles if they did not possess some very special resistance. Presuming that this immunity is due in part to the presence of a definite chemical, several conclusions would then seem warranted. This chemical is not soluble in water, as then it would always be in the circulation in sufficient amounts to prevent and cure the disease. It is destroyed in the process of emaciating, as otherwise, when the muscles atrophy, it would be thrown into the circulation in sufficient amounts to either cure the disease, or by killing the bacteria in large numbers to set free enough endotoxines to kill the patient. Research with the various chemical solvents at our disposal would be indicated.

During the years 1912 to 1915 Dr. R. E. McBride, of Las Cruces, New Mexico, and I did some research work in tuberculosis along the lines indicated above. We inoculated, both subcutaneously and intraperitoneally, guinea pigs with sputum containing tubercle bacilli obtained from human cases. The muscle tissue used was obtained from Angora goats. This animal is readily obtainable in southern New Mexico and was selected on account of the high species immunity to tuberculosis. The muscles of the flank were used, and pieces were placed in a 1 per cent. solution of tricresol, which is strong enough for purposes of sterilization.

In preparing the material for injection a piece was placed in a stone mortar, of course under aseptic conditions, and thoroughly ground up. The connective tissue was discarded. A syringe with a rubber plunger was used, and the mixture readily passed through a 20 gauge needle. The mixture was made fresh each time before using.

At first we injected 1 cc at a time. The injections were made two or three times a week, and were given subcutaneously. Infected animals that did not receive injections of muscle tissue were used as controls. Sometimes the treated animals developed tuberculosis and died in the same period of time that the controls did. Occasionally the onset of tuberculosis was delayed for varying periods, and several times it was prevented. Several instances occurred in which lesions that were apparently tuberculous healed on continued treatment with this preparation.

No local abscesses developed as a result of these injections. Lumps formed which lasted for ten days or two weeks, but these were finally absorbed. There was no general reaction, and at no time was there any evidence of anaphylaxis.

We then decided to make clinical use of the method. The first point to determine was the danger of anaphylaxis in human cases. Dr. McBride injected subcutaneously into me 3 to 5 cc of this preparation once a week for six weeks. In each instance a small lump formed which was only slightly sore, and which was completely absorbed in from two and one half to three weeks. There was no general reaction.

Dr. McBride then treated three tuberculosis patients who were under his care, of course explaining to them the nature of the treatment, and obtaining their consent in writing. Injections were given twice a week over a period of three months.

I treated a patient in El Paso for five months. A total of forty-eight injections were given, at first every day, and later about every five days. The amount of the mixture injected ranged between one and one half to six cc. The lumps produced were only slightly sore and usually disappeared in three weeks. There was no general reaction.

All these patients were in an advanced stage of the disease, with cavity formation and were not doing satisfactorily.

The results obtained were not conclusive, but were sufficiently suggestive to warrant the statement that improvement resulted from the injections. Other patients under observation, in about the same condition, who did not receive the injections, served as controls.

The resistance of the tissues is no doubt an important factor in other diseases than those of infectious origin. This is suggested in cases of cancer or epithelial malignancy. Our knowledge of cancer has increased very greatly in the past twenty-five years, especially as the result of modern research methods, but the problem is far from solved. There is one point that may throw light upon one phase of our resistance to this condition, and also possibly upon its treatment. It is well known that epithelial malignancy is common in the esophagus, stomach and large intestine and is rare in the small intestine, especially in the duodenum, and also that it is frequently associated with gastric ulcer and very seldom with duodenal ulcer. The study of the causes of these phenomena may develop some very important facts regarding the nature of malignancy and our resistance to it and is well worthy of research. The epithelial cells of the small intestine must have some defensive factor against malignancy that is not present in the other organs mentioned above, and I suspect that secretin is the protecting chemical.

In conclusion I wish to emphasize the facts that the importance of the resistance of the tissues to infection has never received the attention that it deserves and that this is a promising field for research.

ELLIOTT C. PRENTISS

EL PASO, TEXAS

SOME MATHEMATICAL ASPECTS OF COSMOLOGY

(*Continued from page 63*)

II. Cosmology

We come now to a somewhat larger point of view. Cosmogony deals only with the mode of origin of the various celestial objects. But the mode of origin is of no more interest than the mode of dissolution, and both of these are but particular stages in a process of transformation that goes on unceasingly. The study of these transformations in their widest possible aspect is what I understand by the word *cosmology*. It does not belong to astronomy any more than it does to physics and chemistry, for cosmology is as much concerned with the life history of molecules, atoms and electrons and their inter-relations, as it is with the life history of planets, stars and galaxies. If it were a mature subject, instead of being, as at present, a mere infant, the crystal, the cell and the living organism would play a rôle which we might well call vital. To the cosmologist each of these things is a physical unit which comes into existence, plays its allotted rôle upon the stage of time, and passes out of existence. The mode of its organization is definite, its properties are specific, and its dissolution is liable to be more or less abrupt or catastrophic. Throughout all these transformations we recognize that there is something which persists, and that something we call *energy*. Energy itself is not defined, but it can be measured and with that measurement we must remain content, for the thing itself escapes us.

I am sure that I could not proceed much further without being assured by some one that I was taking a great deal for granted. It is necessary, therefore, for us to stop and to make some inquiries as to the nature of what we are trying to do. I take it that science aims to extend the boundaries of human experience to the utmost limits, and endeavors to coordinate the experience already acquired for the purpose that it may be available at command and that it may be used as a basis of prediction for the experiences which we anticipate. In doing this, it is merely extending in a purposeful and conscious manner, and intensifying, a process which begins with each individual in the first waking hours of infancy, but which frequently dies out during maturity, or even before maturity is reached. By the time we take up the process consciously we are a long way from the beginning, and it is a very difficult matter to get a correct perspective of our activities. We know that we are on our way, but we do not know, quite, where we are going.

It is in these difficulties that we turn once more to mathematics for aid; and not in vain. The geometers of Alexandria, some two thousand years ago, had trouble over the proofs of their theorems. They could not agree on what constituted a proof, for no two of them would start from the same "obvious" propositions. This situation led Euclid to attempt a unification of geometry; and for this purpose he laid down a system of definitions, axioms and postulates, once for all, to which he could appeal whenever necessary in the course of the argument. Doubtless this system of axioms and postulates covered the points which were of interest and dispute at that time, so that, although the system was by no means complete, it did bring unity and harmony into the science of geometry. The axioms are of the nature of logical statements, while the postulates are statements, supposed to be obvious, about the fundamental concepts of geometry. Evidently the first proof must rest upon propositions which are not proved, and new postulates are necessary whenever new aspects of the subject-matter are considered.

The rapid growth of mathematics during the seventeenth and eighteenth centuries was followed by a second period of sharp criticism early in the nineteenth century associated with names of Gauss, Cauchy, Abel, Riemann and many others. The foundations of arithmetic and geometry were carefully examined for the purpose of determining whether or not the structures built upon them were secure. The result of this scrutiny was that these subjects were removed from the domain of *nature* altogether. The real number system, for example, is a purely intellectual system. The first steps of its creation were taken unconsciously by rude, perhaps barbaric, people because it was a useful thing. Its completion, through the invention of the irrational numbers, was a definitely conscious operation; but a comprehension of nature of the system was not had until it was derived in a logical manner from a precise set of postulates relating certain undefined elements and undefined terms. There is nothing *obvious* about the postulates; and other number systems can be had by using other postulates. There is nothing *objective* about the real number system. It is simply a definite intellectual creation, which is interesting in itself and frequently useful in the many situations in which we find ourselves.

With slight changes of wording the same statements can be made with respect to geometry. The necessary postulates are different from the postulates of the number systems, because their subject-matter is different; but the development of a geometry from a system of postulates has the same abstract char-

acter as the development of a number system. Naturally, different geometries result from different systems of postulates, and there is nothing *objective* about any of them. The same thing is true about dynamics. It is idle to inquire whether the relativistic mechanics is true, or whether the classical mechanics is true. From the postulational point of view they are both true, if they are logically above reproach.

Indeed, having once risen to the level of the postulational method, the construction of intellectual edifices upon new systems of postulates becomes a fine game. Some systems of postulates will be found barren, for apparently nothing can be derived from them. Others are fertile, in the sense that at least a small body of theorems can be derived; while a very few others are extremely fertile, and so useful in their applications that we do not think of them merely as intellectual sports; they become sciences, such as algebra, geometry and mechanics. There is this interesting fact, however; so far as I am aware, no very fertile system has been built upon postulates which were not suggested more or less immediately by our common experiences in life.

On account of its philosophical bearing, I regard the development of the postulational method as the greatest achievement of the mathematicians of the nineteenth century. Not only has it made clear the nature of mathematics, but it has also thrown a flood of light upon the nature of the physical sciences, a fact which is well brought out by E. W. Hobson in his recent book, "The Domain of Natural Science." To him who would gain the widest possible point of view, that is to say, the cosmologist, it is a downright necessity.

There is a fundamental difference, however, between mathematics and the natural sciences. The pure mathematician is interested only in logical systems. He is, therefore, quite free from entanglements with observation and experiment; his postulates can be any consistent set of statements that his fancy dictates. The natural scientist is interested primarily in experience. Logical systems would have no interest to him whatever, if it were not for the extraordinary fact that he finds certain logical systems extremely useful. He is free in the choice of his postulates, therefore, only on those points with regard to which he can have no experience whatever, directly or indirectly. In order that I may speak the same language as the mathematician, I shall understand the word *postulate*, as used in cosmology, to refer only to statements about matters with respect to which we are and always will be entirely free from experience. Similar statements, which observations or experiments may show to be in harmony or in conflict with experience, I shall call *hypotheses*. Hypotheses have the nature of tentative postulates, and are therefore strange things to a mathematician. A mathematical system is closed in the sense that it contains only the assigned postulates and the theorems which are logically derivable from them. A cosmological scheme, which deals with experience, is necessarily an open one. One can not write down all the postulates, once for all, nor the undefined terms, for there is nothing to suggest that we have arrived at the outermost limits of experience, or even that such limits exist.

Notwithstanding the fact that each of us is free in the choice of his postulates, so that *no system of postulates merits the claim of exclusiveness*, still, on account of our common heredity and experience, it is true that certain postulates are commonly made, and have, therefore, something like a universal appeal to our esthetic sense. Let me write down a few of these postulates which seem to me to belong to a normal system:[36]

(1) *There exists a physical universe, external to myself, with which I have experience.*

I am not sure whether or not all the adherents of the modern theory of relativity use this postulate. At times it seems to me they do not. At any rate, there are people who seem perfectly happy with a mathematical formula. As for me, I am not happy unless I can see what lies behind the formula; that is to say, a qualitative understanding of a situation is of even greater importance than a quantitative one. Thus $\frac{x^2}{16}+\frac{y^2}{9}=1$ is an exact relation between the magnitudes x and y, whatever they may be. But it makes a great deal of difference whether x and y are to be interpreted as the cartesian coordinates of a point, or as the position and velocity of a particle in simple harmonic motion, or perhaps something else. A mathematical formula is not the goal of cosmology.

(2) *The geometry of the physical universe is euclidean.*

(3) *The time of the physical universe is newtonian.*

The purpose of postulates 2 and 3 is evident. Previous to the exposition of Einstein's doctrine of relativity they would doubtless have commanded universal assent, but the unusual character and the beauty of Einstein's system, together with the simplicity with which it enables us to anticipate certain very delicate phenomena in the domain of physics and astronomy, have won many adherents to it, so that the classical postulates 2 and 3, at least for the time being, are not universally adopted. Inasmuch

[36] See also MacMillan, "Some postulates of cosmology." *Scientia*, February, 1922.

as the relativists do not concern themselves with a physical basis for the transmission of radiant energy, their scheme being a purely mathematical one, I am not sure that they have any need for postulate 1. As a well-known physicist expresses it, they explain terms of the second order beautifully, but they do not explain terms of order zero at all. There are many of us who prefer the terms of order zero, and are unwilling to sacrifice our intuitions upon the altar of the terms of order two. Let us not forget that success or failure argues nothing for the truth or falsity of either system. The relativists have had great successes at certain points where the classic system has so far failed. That is all. This suggests that great discoveries are waiting for some one among the classicists, and the successes of the relativists should be stimulating.

(4) *The physical universe is not bounded in space.*

Not all people, by any means, think of the universe as unbounded. I think I can safely say that nearly all mathematicians do, and many of the more abstract type of physicists and astronomers; nevertheless, it must be admitted that many scientists prefer to think of it as finite. There is no admitted agreement.

(5) *The physical universe is continuous in time.*

Physical things do not disappear from one position in space, only to reappear at the succeeding instant at some distant position. Discontinuities of this type do not occur. Neither does any body act upon another and remote body instantaneously; which is equivalent to saying that energy is transmitted at a finite velocity. Furthermore, something does not become nothing, and nothing does not become something.

(6) *The distribution of matter throughout space is uniform if considered on a large scale,* by which I mean, the limit of the mean density of a spherical volume having any center tends towards a definite constant, different from zero, as the radius of the sphere increases indefinitely.

Consider a series of concentric spherical surfaces, the radii of which are proportional to the successive integers 1, 2, 3, . . . , and suppose n stars are placed upon the nth surface. We can regard such a system as a universe which is not bounded in space (postulate 4). The total number of stars is infinite, but the mean density of the volume of the nth surface is proportional to $\frac{n+1}{n^2}$, which has the limit zero as n increases. The distribution of matter in such a universe is not uniform. If, however, we place n^2 stars upon the nth surface, the mean density of the nth sphere is proportional to $\frac{(n+1)\ (2n+1)}{n^2}$ which has the limit 2 as n increases indefinitely. If the stars were scattered over the surfaces of the spheres at random, so as to avoid peculiar distributions, then we would say that the matter in this universe was uniformly distributed. (Considered on a small scale, matter is never uniformly distributed over any volume; even water is not uniform from this point of view).

If, however, all these stars radiate the same amount of light, and if the law of intensity of radiation is strictly the inverse square law, then the amount of light received at the center of the sphere is the same from each sphere, and since the number of spheres is infinite, the total amount of light received at the center is infinite; if, however, we allow for the occultation of one star by another, the entire sky is only as bright and hot as the disk of the sun. This result follows even for the universe in which n stars only are distributed over the nth sphere, for the amount of light received at the center from the nth sphere is proportional to $\frac{1}{n}$, and, as we know, the series $\Sigma \frac{1}{n}$ is divergent. We shall have occasion to return to this point later.

(7) *There exist physical units which, for a finite interval of time, preserve their identity and exhibit characteristic properties.*

(8) *The sequence of physical units is infinite both ways, like the positive and negative powers of a positive number.*

The term "physical unit" corresponds largely to the word "object." The smallest physical unit which we recognize at the present time is the positive electron, and the largest one is the galaxy. In ascending scale, we have electrons, atoms, molecules, ordinary masses, stars, star clouds, galaxies. We ourselves and the objects with which our thoughts are normally concerned belong to the class of ordinary masses, and the variety of the physical units which belong to this class is truly amazing. No two objects are exactly alike, yet resemblances are sufficiently strong to permit classification, and even to suggest the postulates on which the mathematician bases his number system.

Ordinary masses are built out of molecules; molecules are built out of atoms; atoms out of electrons. Likewise the stars are huge masses of gas; the star clouds are vast aggregations of stars; and the galaxy is an aggregation of star clouds. Each physical unit is built up of units of the next smaller order, and our method of accounting for the properties of objects is to recognize a differentiation in the parts of the object. If there existed a smallest physical unit there would be no differentiation, and hence it would have no properties.

It will be observed that ordinary masses are just in the center of our list of physical units. Shall we go back to the old notion that we are the natural center of the universe, or shall we regard this as a mere appearance, due to the fact that it is more and more difficult for us to have experience with those units which are more and more remote from us in the physical scale? We are at the center, because the center is everywhere. Two atoms of gold seem just alike because we are not very familiar with atoms of gold, and two electrons seem to be identical merely because of our profound ignorance. Super-galaxies exist though we have had no experience with them at all; likewise, hyper-super-galaxies,[37] and so on indefinitely. Things do not cease to exist merely because we are ignorant. We should beware of the tacit postulate, which often crops out, "Only those things exist with which we have had experience." Nature is much broader than experience, and we must have plenty of room for expansion.

(9) *The phenomena of nature occur always in such a way that certain relations remain invariant.*

This postulate asserts merely that science is possible, and the main purpose of science is to ascertain these invariants.

(10) *Every physical situation is definite and determined, both as to its extensions in space and its sequential states in time;* or, in simple language, nature is never in doubt.

This is not the case in mathematics. The value of a function at a point may be quite indeterminate, and the limit of the function as we approach a point may depend upon the mode of approach. Imagine all space filled with matter uniformly distributed. (I am speaking mathematically now), and that Newton's law of gravitation holds. What is the resultant acceleration on any given particle. Let p be the particle and let O be a point at a distance R from p. Let S be the sphere with center at O which passes through p, so that R is its radius. Then the attraction of this sphere upon the particle p is directed towards O and its magnitude is proportional to R. Take a second sphere S_1 with its center at O and its radius $R_1 > R$. Then the resultant attraction of the spherical shell between S and S_1 upon the particle p is zero however great R_1 may be. We conclude that the resultant attraction of the matter in all space upon the particle p is the same as the attraction of the sphere S_1, which is proportional to R and directed towards O. But as the point O is arbitrary, both as to distance and direction, the resulting attraction is completely undetermined. This is the Neumann-Seeliger proposition. Similarly, the attraction of a thin disk upon one of its own points is completely undetermined. But these are mathematical situations. According to the postulate, such situations do not arise in nature.

(11) *In every region of space, however small, there exists at least one physical unit.* The postulate denies the existence of empty space, and asserts on the contrary that every portion of space is infinitely complex.

(12) *The energy within a region of space does not increase or decrease, unless there is a corresponding decrease or increase in some other region of space.* This is the doctrine of the conservation of energy to which physicists were led about the middle of the last century. It possesses some quality that appeals to the esthetic sense, for it has been adopted, almost universally.

(13) *The universe does not change always in any one direction.* Using figurative language—the universe is not like a stream which flows steadily from one unknown region to another. It is like the surface of the ocean, never twice alike and yet always the same. At the same time that the physicists were formulating the doctrine of the conservation of energy, which is sometimes called the first law of thermodynamics, they also formulated the second law of thermodynamics, which has been stated in various ways, but the essential idea is that energy is constantly being degraded into the form of heat and radiated away; the energy available for useful work is always diminishing, or in modern terms, the entropy is always increasing. Physicists and chemists have been very successful in predicting phenomena by means of this law, and it has a thoroughly reputable standing. Nevertheless, it has always met with violent opposition and dislike. It is out of harmony with the idea contained in postulate 13, and therefore it is unpopular. As I see it, the second law of thermodynamics is similar to the statement that under natural conditions water always flows down hill. This is true enough, but if it were the whole truth one could not avoid wondering why the water had not all gotten to the bottom of the hill long ago. The statement is true of water in the liquid state. but in the state of vapor it is equally natural for water to rise. We shall see later that the second law of thermodynamics states only one half of the complete process.

WILLIAM D. MACMILLAN
THE UNIVERSITY OF CHICAGO

(*To be continued*)

[37] This word is due to Moulton.

THE JOHN SCOTT MEDAL FUND

THE following is an extract from Power of Attorney to carry out certain provisions in the will of John Scott dated April 2, 1816.

. . . that the interest and dividends to become receivable . . . be laid out in premiums to be distributed among ingenious men and women who make useful inventions; but no one of such premiums to exceed twenty dollars, and along with which shall be given a copper medal with this inscription "To the most deserving" comformably to the tenor of the will of the said testator, John Scott, deceased.

By decree of the Court of Common Pleas of Philadelphia the administration of the trust was modified as follows:

And now, this nineteenth day of February, A.D., 1919, the Report of the Master having been duly filed and no exceptions having been taken thereto, it is adjudged and decreed that the same be confirmed, and that the Board of Directors of City Trusts having in charge the trust created under the will of John Scott, deceased, be authorized and directed in the administration of said fund to distribute the income arising from the fund as it stands with its accumulations as of the date of this decree, in premiums to be distributed among ingenious men and women who make useful inventions, but no one of such premiums to exceed Eight Hundred Dollars ($800) in value (increased under Decree of Court, dated November 29, 1921, to $2,000); and along with such premium shall be given a copper medal with this inscription "To the most deserving" comformably to the tenor of the will of the said testator.

It is further ordered and decreed that in the selection of the recipients, the said trustees shall be at liberty to make such rules and regulations for enabling them to make a wise selection of beneficiaries either by the selection of an advisory board or otherwise, as they may deem best. The premiums shall be awarded for useful inventions which shall include any inventions that will be useful to mankind in the advancement of chemical, medical or any other science or in the development of industry in any form; the test being that the invention is, in the judgment of the trustees, definitely accomplished, and that it may add to the comfort, welfare and happiness of mankind.

The following resolution has been adopted by the Board of Directors of City Trusts:

Resolved—that the award of medals under the John Scott Medal Fund be made hereafter upon the recommendation of an Advisory Board, to consist of five persons, to be appointed by the Board of Directors of City Trusts; three to be nominated by the National Academy of Sciences, one by the University of Pennsylvania, and one by the American Philosophical Society; all of said nominees to be acceptable to the Board of Directors of City Trusts; the recommendations of the Advisory Board to be made on a majority vote:

Personnel of the Advisory Committee:

National Academy of Sciences:
H. H. Donaldson,
Theobald Smith,
W. B. Scott.
University of Pennsylvania:
Arthur W. Goodspeed.
American Philosophical Society:
Samuel M. Vauclain.

Awards of the John Scott medal with prizes of $1,000 have been made as follows:

William G. Houskeeper, E.E., Research Physicist, Bell Telephone Laboratories, Inc.

For the invention of a method for sealing through glass metals having widely different expansion coefficients. It is popularly known as "the copper-glass" seal and is gas-tight.

This work has made possible in a fundamental way the practical use of vacuum seals in general between glass and metals.

The process is very valuable in the construction of high power electron tubes and other similar devices used in engineering in recent years.

Charles H. Norton, Inventor and Engineer, Worcester, Mass.

For the development of grinding and the invention of apparatus for precision grinding.

To Mr. Norton is due the development of grinding as a distinct manufacturing process with or without the preliminary use of other cutting tools.

The design of special machine tools effectively to apply these principles to manufacture on a large scale. The Norton processes have revolutionized production in many industries, notably in one of our largest—the automotive.

Ross G. Harrison, Ph.D., M.D., professor of comparative anatomy, Yale University.

For devising and developing the method and apparatus by which he was the first able to graft together whole bodies of vertebrates of the parts and organs of different individuals and even of different species and for inaugurating the method of "Tissue Culture," by which parts removed from the living animal may be kept alive and studied under the microscope, for months or years.

In Roux's *Archiv für Entwicklungs Mechanik*, Vol. 7, 1898, he published results of his work on grafting the tail of one species of tadpole onto the body of another species and the resulting regeneration of various tissues and organs. Such grafted forms were reared to adult life, the anterior part of the body preserving the characteristics of one species, the posterior part that of the other species. From 1902 to 1919 he continued such grafting experiments on limbs which were taken from one individual or species and transplanted to another, devoting particular attention to the regeneration of nerves in the transplant. In later years (1915–21) he continued such work with reference to the symmetry of transplanted limbs. All of this work opened a field for surgical transplantation of organs and limbs of higher animals which bids fair in time to be of great value to mankind.

A second line of work of even greater present importance, which was first inaugurated by Dr. Harrison, is that known as "Tissue Culture." In 1907 (Anatomical Record, Vol. 7), he first studied the growth and development of a living developing nerve fiber. This paper was followed in 1908–14 by other important contributions in which he described in detail this new method of research and demonstrated its unique value in the study of different kinds of living cells. Dr. Harrison's pioneer work in this field has been recognized by election to honorary membership in various foreign scientific societies and by the award of the gold medal of the Australian Zoological and Botanical Society in 1914.

Marshall Albert Barber, Ph.D., expert in malaria research, U. S. Public Health Service, jointly with Robert Chambers, Ph.D., professor of microscopic anatomy, Cornell Medical College.

Dr. Barber—for his invention of the pipette method and the apparatus for its control; used for the isolation of single micro-organisms and the injection of substances into single living cells.

Dr. Chambers—for his improvements in the micro-dissection apparatus, the extension of its use to the anatomy of single cells and the determination of the physical structure of protoplasm.

The micro-dissection apparatus consists of a device for the delicate movement and control of a pipette or needle in three planes.

The apparatus is attached to the stage of a microscope and the object, which is in a hanging drop of fluid under a glass slip, is manipulated by the observer as he views the field.

The needles have diameters of 1/25400 of an inch or less. The pipettes are about 4 times as large. By their use single cells can be removed, cut, dissected—or injected with various fluids. This apparatus, and the technique which has grown up with it, permit an extension of anatomical studies to the details of living cells. Through these studies important contributions to our knowledge of the living substance—protoplasm—have been made. This apparatus has thus opened a new field for investigation.

Orville Wright.

He was a pioneer in the art of aviation; was the first to experiment with wing warping; invented the system of control used in all flying machines to-day and built a motor-driven aeroplane in which the first flight in history was made.

From 1910 to date he has been at work in designing and testing aeroplanes, automatic stabilizers, wind tunnel research and research in every line pertaining to aviation.

His inventions in the field of aviation are universally used and his contributions are primarily responsible for the great advance in this art.

GILBERT VAN INGEN (1869–1925)

PROFESSOR GILBERT VAN INGEN, since 1903 a member of the faculty of geology of Princeton University, died at his home in Princeton on July 7. He was born on July 30, 1869, at Poughkeepsie, N. Y., where his father was professor of art in Vassar College. He was of Dutch descent, both his parents having been born in Holland in families many of whose members had been gifted artists, sculptors and musicians. He received his early education in a private school in Poughkeepsie and, while still a boy, acquired from his father a dexterity in the use of the pencil and brush which was to prove of great use to him in after life.

He inherited a keen interest in art, but early developed an even deeper interest in botany and zoology, and spent much of his spare time in the fields and woods of the beautiful countryside around his native town, studying the plants and animals which he found there. When ready to enter college in 1886, he had fully decided to become a botanist and went to Cornell University to study toward that end. He was interested in all branches of natural history, however, and in his first year at Ithaca attended Professor H. S. Williams's lectures on geology and paleontology. He was so deeply impressed by Professor Williams's personality and lectures and by the interest of these subjects that he abandoned his plan of becoming a botanist and determined to devote his life to the study of stratigraphy and paleontology. He studied geology and paleontology under Professor Williams and Professor C. S. Prosser during the college years 1886–87 and 1887–88, and acted as assistant to Professor Williams in field work in the spring and summer of 1889. He was then appointed assistant geologist on the staff of the U. S. Geological Survey and spent most of the year 1890 and the early part of 1891 in a study of the subcarboniferous rocks of Missouri, under the direction of Professor Williams and Dr. G. K. Gilbert. In the fall of 1891 he returned to Cornell as assistant to Professor Williams, and when the latter went to Yale in the following year, he went with him and spent the academic year 1892–93 at that institution, studying paleontology under Professor Williams and zoology under Professor A. E. Verrill. He did not receive a degree at either Cornell or Yale, but got an excellent training in field and laboratory methods of research and valuable experience in teaching. In 1893 he went to Columbia as assistant in paleontology and remained there for eight years, being appointed curator of the geological collections in 1895. While at Columbia he did much to help Professor J. F. Kemp build up the geological and paleontological collections which are so valuable a part of the present department of geology of that university.

While in New York he served as editor of the *Transactions* of the New York Academy of Sciences and of the paleontological department of the New International Dictionary. In his summer vacations he carried on field work on the Paleozoic rocks of

eastern North America, visiting the region about St. John, New Brunswick, under the guidance of Dr. G. F. Matthew and Dr. W. D. Matthew in the summer of 1894, the shores of Lake Champlain in 1893, 1895 and 1899, the Hudson and Mohawk Valleys in 1897 and western New York in 1898. The summer of 1896 he spent in field work on the Silurian rocks of the Batesville region, Arkansas, a district which he visited again in 1905. In 1901 he joined the staff of the New York Geological Survey as assistant paleontologist, and for two years worked on Paleozoic problems in that state, notably on the Potsdam and Ordovician of the Lake Champlain region and the Silurian and Devonian of the vicinity of Kingston, in the Hudson Valley.

In 1903 Professor Van Ingen married Miss Harriet Galusha, of Rochester, New York. In the fall of that year he was called to Princeton as assistant in geology and curator of invertebrate paleontology. He remained at Princeton for the rest of his life, being made assistant professor of geology in 1908 and associate professor in 1921. The fourteen years from 1903 to the outbreak of the World War in 1917 were the most fruitful years of his life. He came to Princeton with a training and experience which, combined with his energy and enthusiasm, made him an invaluable addition to the department of geology; and he came, too, at a time when the opportunities for constructive work in the department were as great as were this energy and enthusiasm. The rapid growth of the university and the expansion of its scientific departments which took place during President Woodrow Wilson's administration required much wise constructive planning and a tremendous amount of work by the faculty. The department of geology outgrew its quarters, and plans were made for a great modern laboratory which should be ample for the department's needs for years to come. No such laboratory as this had ever been built in America. There was no model which could be copied; the building had to be planned literally from the ground up. Professor Van Ingen was appointed one of a committee of three to advise and assist the architect in drawing up plans; and to him is due in a very large measure the fact that Guyot Hall became, as it yet remains, one of the best-planned and best-equipped natural science laboratories in the world. The added facilities of the new building and the additions to the teaching staff and endowment which came with them led a large number of students to enroll in the courses in geology and paleontology and caused a notable increase in the number of graduate students specializing in those sciences. This increase in enrollment made necessary increased equipment, a large library, changes in the curriculum and increased teaching duties in both the laboratory and the field; above all, they called for an immense amount of work by the secretary of the department of geology. This work Professor Van Ingen undertook with a whole-hearted enthusiasm and an indefatigable zeal which earned for him the gratitude of the university and the affection of his colleagues and students. He was especially interested in the work of the graduate students, and gave unstintingly of his time and energy to their instruction. He took them into the field in the Paleozoic districts of New York, New Jersey and Pennsylvania at every opportunity. When he first came to Princeton he found that he could conveniently extend the field of his studies of Paleozoic stratigraphy and paleontology from New York into New Jersey, Pennsylvania and Maryland; and he combined research with the field instruction of his students in those states and New York, visiting many localities and gathering large and very valuable collection of fossils. In 1912 he organized and led an expedition to southeastern Newfoundland. The results were so gratifying that other expeditions to the same region went out under his leadership in 1913 and 1914. Many interesting problems were studied and thousands of fossils and rock specimens were collected. Four of the students who were members of the expeditions later published doctorate theses based upon this field work.

Professor Van Ingen was an ideal field instructor, and his many students cherish memories of their days in the field with him. He was no less helpful and inspiring in the laboratory, being as much interested in his students' problems as were the students themselves; and nothing that would help one of his men in his research was too arduous or inconvenient for his attention. He was an expert and enthusiastic photographer, perhaps partly because of his artistic inheritance, and the advice and assistance which he gave to his students in the preparation of the illustrations for their theses was invaluable. He liked to have his students about him, and to many of them his house was almost a second home. He was generous to a fault; and, when he believed that the interests of the university or of his students would be advanced thereby, he gave of both effort and funds without thought of the future. Some of his students remember with deep gratitude the helping hand which he extended in the hard places of their early careers.

The entrance of the United States into the World War brought new and unaccustomed duties to many members of the Princeton faculty. The university, always famous as a center of patriotism, began training prospective army officers even before hostilities began, and offered all its facilities to the government as soon as war was formally declared. The campus became an armed camp, and its professors turned

from teaching the arts of peace to instructing in the art of war. With his characteristic energy, Professor Van Ingen began preparing himself, the younger instructors and the graduate students of his department to do efficiently what it seemed most probable that they would first be called upon to do—give instruction in map-reading and interpretation to undergraduates and alumni of the university who were desirous of fitting themselves for commissions in the army. When the university actually began the training of these men, therefore, he was placed in charge of that branch of instruction. When the government asked the university to set up a school of military aeronautics for the preliminary training of candidates for commissions in the Air Service, he was chosen to be president of the academic board of the school, responsible for all the instruction given except the military drill. He organized the school and remained as its academic head until the end of the war. It was under the tremendous strain of this work that his health broke down. He suffered a nervous collapse, and later contracted a serious case of influenza, from the after-effects of which he never recovered.

B. F. HOWELL

PRINCETON UNIVERSITY

SCIENTIFIC EVENTS

THE AUSTRALIAN COMMONWEALTH SCHOOL OF ANTHROPOLOGY[1]

AFTER nearly two years' effort, the Australian National Research Council has succeeded in its project for establishing a Commonwealth School of Anthropology, to be attached to the University of Sydney. In December 1923 the Commonwealth government expressed approval of a scheme submitted to it; in the following year, however, an officer selected by the British government to advise Australia in the matter of administration of territories, reported very strongly against the proposal to use such a school for the training of officials. In consequence, government interest flagged. Renewed efforts, supported by the Australasian Association for the Advancement of Science and the universities, were made in September, and, largely as the result of a visit from Professor Elliot Smith, who brought unofficial word of warm American sympathy, the prime minister promised to provide £1,000 per annum towards the expenses of a chair. The estimated yearly requirement being £2,500, the respective states were then asked to contribute the balance of £1,500 between them on a population basis. New South Wales, Victoria, Queensland and Tasmania agreed to provide their shares, and South Australia is practically certain to fall into line; Western Australia remains uncertain. The Research Council, therefore, has now asked the senate of the University of Sydney to consider the immediate appointment of a professor and the general arrangements for the new school. In doing so, it has laid emphasis on the following points: (*a*) The main work of the chair both in teaching and research should be in the field of social anthropology rather than on the physical or anatomical side, though provision should be made for this also. (*b*) In view of the training of students for government service in Papua and the Mandated Territories, and for specialized work in the Pacific, the professor chosen should have had actual field experience. (*c*) Though the routine work of the new chair will be under the control of the University of Sydney, it is urged that a permanent advisory committee, containing representatives of the commonwealth, states and research council, should be appointed, to assist in the organization of field research.

[1] From *Nature*.

SCIENTIFIC RESEARCH UNDER THE GOVERNMENT

REPRESENTATIVES of technical and scientific bureaus of the government met in the Interior Building on June 17 to formulate plans for the conduct of scientific research in the government service. General H. C. Smither, chief coordinator of the Budget Bureau, presided. The object of these conferences is to have frank, open discussion of the problems confronting the scientific worker, to the end that better cooperation and less duplication may result. According to a report in *Industrial and Engineering Chemistry*, the government activities represented were:

Department of Agriculture
- Bureau of Chemistry, W. W. Skinner
- Fixed Nitrogen Research Laboratory, F. G. Cottrell

Department of Commerce
- Bureau of Standards, G. K. Burgess
- Bureau of Mines, D. A. Lyon

Department of the Interior
- Geological Survey, W. C. Mendenhall

Navy Department
- Bureau of Engineering, M. A. Libbey
- Bureau of Ordnance, A. C. Stott
- Bureau of Navigation, E. T. Pollock and W. C. Asserson
- Naval Research Laboratory, Paul Foley
- Bureau of Aeronautics, R. M. Parsons
- National Advisory Committee for Aeronautics, G. W. Lewis

Smithsonian Institution
- A. Wetmore

Treasury Department
- Public Health Service, H. S. Cumming and G. W. McCoy

War Department
Office of Engineers, P. B. Fleming
Ordnance, J. E. Munroe
Air Service, W. R. Davis and R. L. Walsh
Signal Office, P. S. Edwards
Chemical Warfare Service, C. R. Alley

The importance of maintaining a high morale among the scientific force and its bearing on the results achieved was emphasized. Two factors influence the morale generally—reclassification and appropriations. These factors create an uncertainty about tenure of office on the one hand and permanence of activities on the other. It was the sense of the conference that morale among the scientific personnel must be strengthened and that adequate provisions for promotion of both financial and honorary nature, as well as the stabilization of research by safeguarding it against the effects of retrenchment, would go far towards accomplishing this end. Dr. Cottrell suggested the advisability of having some agency set up as a trustee of accumulated funds. Contingent assets to the government might be used for such a cause. He then cited the patent situation as an illustration and pointed out that a simple article might be turned out which might have tremendous returns, whereas a serum of great importance to the human race would yield little financial return. He suggested that profits from the exploitation of the one might be used in the production of the other. He called attention to the fact that the proposed patent bill had a clause providing for the creation of an organization to handle profits from patents and distribute them in rewarding inventors. In other words, it is his idea that we should look forward to the time when a fund derived from revenue will go a long way towards making fundamental research self-sustaining. He was asked to put his ideas in tangible form for presentation at the next meeting of the conference.

General Smither appointed the following committee to study the manner of stabilizing the sinews of research in the government service with relation to the appropriation of money by the congress: Surgeon General H. S. Cumming, *chairman*, G. K. Burgess, F. G. Cottrell and George Otis Smith.

The matter of medical aides in the scientific units of the government service was next discussed. It was the consensus of opinion that some provision should be made for adequate medical attendance at government bureaus where work of a general hazardous nature is being conducted. Surgeon General Cumming was asked to devise some plan whereby ways and means may be found, either by legislative enactment or otherwise, to give him the authority to assign medical aides to such bureaus.

The next conference will be called in September.

THE BRUSSELS MEETING OF THE INTERNATIONAL COUNCIL OF RESEARCH

At the General Assembly of the International Council of Research held at Brussels, July 7 to 9, 1925, the agenda consisted principally of propositions submitted by Denmark, Holland and Switzerland to amend certain statutes of the International Research Council. The effect of the original statutes was the exclusion of the Central Powers. Article I (1) based membership in the new organizations upon the Resolution of London (Oct., 1918), namely: "Les nouvelles Associations reconnues utiles au progrès des sciences et de leurs applications seront établies, dès maintenant, par les Nations en guerre avec les Empires Centraux, avec le concours éventuel des Neutres." Article III (3) names the countries originally admitted or admissible. The proposition to let down the bars was presented on the part of Holland by Professor Lorentz.

The delegates from the United States were Vernon Kellogg, *chairman*, W. W. Campbell and Charles E. St. John, who had been instructed by the National Research Council to favor and to work openly for making its councils and unions international in fact as well as in name. The vote upon one proposition is instructive and very illuminating as it illustrates the extent to which political rather than scientific considerations controlled.

Yes—10 Nations

	Weight
Denmark	1
Great Britain	5
Holland	2
Italy	5
Japan	5
Norway	1
South Africa	1
Sweden	2
Switzerland	1
United States	5
	28

No—6 Nations

	Weight
France	5
Belgium	2
Czecho-Slovakia	3
Egypt	1
Morocco	1
Poland	4
	16

Not Present

	Weight
Australia	2
Brazil	5
Canada	2
Chili	1
Greece	1

Mexico	3
Monaco	1
Peru	1
Portugal	2
Siam	2
Uruguay	1
Yugo-Slavia	3
	24

NOT VOTING

Spain	5

It is needless to say that there was great disappointment over the outcome and that there were grave fears for the future of a scientific association international only in name.

Near the close of the last session Professor Gullstrand, president of the Royal Society of Sweden, expressed clearly his deep sense of the danger that faces the present international scientific organizations if the situation is not relieved in the very near future. Similar expressions of disappointment and apprehension were voiced by Kellogg of the United States, Knudsen of Denmark, Lyons of England, Vegard of Norway and Lorentz of Holland, expressions received with approval by the majority of nations represented.

It was the general opinion that the statutes of the International Council of Research should be amended at the earliest possible date, so that a change in the statutes would not require a two thirds majority. The absurdity of the present condition becomes apparent when it is noticed that a unanimous vote at the assembly would not have been sufficient to effect a change in the statutes.

Several procedures are open for accomplishing the ends sought. That which seemed to find favor was action by the Executive Committee in calling a special assembly at an early date or a vote by letter-ballot conducted by the executive committee at the request of one third of the weighted membership.

The other item on the agenda, the appointment of a committee for the study of the relationships between solar and terrestrial phenomena, received favorable action. The composition of the committee is S. Chapman (*chairman*), G. Abetti, C. G. Abbot, H. Deslandres, G. Ferrié, C. E. St. John, G. C. Simpson and C. Störmer.

CHARLES E. ST. JOHN

THE JOHN T. SCOPES SCHOLARSHIP FUND

THE scientists who were ready to testify in behalf of Mr. Scopes, recently convicted under the anti-evolution law of Tennessee, are sponsoring the raising of a scholarship fund which will enable Mr. Scopes to continue his scientific training as soon as possible.

It is Mr. Scopes's desire to undertake graduate work in some branch of natural science. At present, however, he is without a teaching position or other means of obtaining the necessary money. Although he has been offered numerous lucrative lecture and stage engagements which would net him many thousands of dollars, he has refused them, wishing to avoid even the appearance of self-exploitation. Impressed with Mr. Scopes's intellectual qualities and modesty, and believing that he is entitled to some substantial recogniiton for the trying experiences that he has undergone in the service of science, and of liberty of thought and speech generally, the scientists who were associated with the defense have organized a committee to raise a scholarship fund of $5,000 to enable Mr. Scopes to undertake graduate work at an institution of higher learning of his own choosing during the next few years. Dr. Maynard M. Metcalf, of Oberlin College and the Johns Hopkins University, the first scientist to testify in Mr. Scopes's behalf, has consented to act as chairman of the scholarship fund committee; Dr. Kirtley F. Mather, of the Harvard Geological Museum, Cambridge, Mass., is vice-chairman, and Watson Davis, managing editor of Science Service, Washington, D. C., will act as secretary-treasurer.

Other scientists who came to Dayton to testify for the defense include: Professor William A. Kepner, University of Virginia; Dr. Jacob G. Lipman, director Agricultural Experiment Station, New Brunswick, N. J.; Dr. Charles H. Judd, University of Chicago; Dr. Fay-Cooper Cole, University of Chicago; Wilbur A. Nelson, Tennessee state geologist; Dr. Winterton C. Curtis, University of Missouri; Dr. W. M. Goldsmith, Southwestern University; Dr. H. H. Newman, University of Chicago; Dr. Frank Thone, Science Service.

It is hoped that a sufficiently large portion of the fund can be raised within a week or two so that Mr. Scopes can make his plans to enter upon his graduate work this fall. Contributions can be sent to any member of the committee and they will be promptly acknowledged. Scientists who will act as chairmen for various regions of the country will shortly be designated and will have charge of the raising of the fund in their particular geographical location.

SCIENTIFIC NOTES AND NEWS

CORRESPONDING members of the Royal Geographical Society of Great Britain have been elected as follows: Senor Don Luis Cubillo, director of the Geographical Institute, Madrid; The Reverend Father Josef Fischer, S.J., of Feldkirch, Austria; Mr. A. P. H. Hotz, C. B. E.; Professor Emmanuel de Martonne, professor of geography at the Sorbonne, Paris; Professor Eugenius Romer, professor of geography at the

University of Lwów, Poland; General Nicola Vacchelli, director of the Military Geographical Institute, Florence, and president of the International Geographical Union; Dr. F. C. Wieder, librarian to the University of Leiden.

Signor de Giuseppe de Michelis, commissioner general of emigration, has been appointed president of the International Institute of Agriculture. He was minister of agriculture in the Nitti and Giotti cabinets.

C. Thurston Holland was elected president of the International Congress of Radiology, recently held in London.

Gustave André, professor in the National Institute of Agronomy, has been elected to the section of rural economy of the French Academy of Sciences.

Professor Bohuslav Brauner, director of the Chemical Institute of the Charles University of Prague, has been elected an honorary member of the Russian Physico-Chemical Society, Leningrad.

Mrs. Clara E. Speight-Humberstone, of Toronto, has been elected a member of the Royal Astronomical Society of France.

The Royal Spanish Academy of Medicine conferred a degree on Dr. Charles H. Mayo, Rochester, at a recent meeting in Madrid.

A statue of John Frank Stevens, of New York City, who planned and carried out the construction of the railway through the Rocky Mountains, was unveiled by his grandson with appropriate ceremonies on July 22. The statue, which is bronze and of heroic size, is placed on the crest of the Continental Divide at Summit, Montana. Mr. Stevens, who is now seventy years old, received this year the award of the John Fritz medal.

The pupils of Dr. y Alvarez E. Pinerúa, who retired some months ago from the professorship of chemistry at the University of Madrid, recently presented to him at a formal session in the assembly hall of the National Academy of Medicine a volume containing a reprint of his works. The session was attended by prominent representatives of the schools of medicine, pharmacy and science.

A special meeting of the South Jersey Section of the American Chemical Society was held at the du Pont Club, Carneys Point, N. J., on June 9 in honor of Mr. Arthur G. Green, F.R.S., the English authority on dyes.

R. A. Cattell, formerly superintendent of the petroleum experiment station at Bartlesville, Okla., has been put in charge of the helium division of the U. S. Bureau of Mines. Five units will be set up within the helium division, to be under the direction of the following men: H. S. Kennedy, natural gas section; C. F. Cook, production section; Dr. Stewart, general section; C. W. Kanolt, research section, and C. W. Seibel, repurification section.

H. H. Hill, chief petroleum engineer, has been placed in charge of the petroleum division of the U. S. Bureau of Mines, and will have supervision of all petroleum investigations conducted by the bureau.

E. D. Gardner, mining and explosives engineer, will serve as acting superintendent of the Southwest Experiment Station of the Bureau of Mines, Tucson, Arizona.

Dr. W. A. Noyes, of the University of Illinois, spent the week beginning June 28 at the Western State College of Colorado, at Gunnison, giving a series of non-technical lectures on scientific topics. The lectures given included the following subjects: "Religion and authority," "The beginnings of accurate knowledge," "The discovery of the composition of water," "Atoms, matter and energy," "The conquest of disease," "International scientific relations," "Who have paid the costs of the war?"

Dr. Frederick W. Sears, district state health officer at Syracuse, N. Y., has been invited to give one of the De Lamar lectures at the School of Hygiene and Public Health of Johns Hopkins University during the coming season.

Professor Kurt Koffka, of the University of Giessen, Germany, lectured at the University of Iowa on Friday, July 10, on "The psychology of the cinematograph." On the following day at a roundtable conference he discussed the "Psychology of Gestalt."

M. le Duc de Broglie, who has for a number of years taken a leading part in physical research in France, delivered the eighth Silvanus Thompson Memorial Lecture in London on July 1.

The announcement of British Civil List Pensions granted during the year ending March 31, 1925, has been issued. It includes pensions of £100 to Miss Maria Birch, in recognition of the services rendered by her father, the late Dr. Walter de Gray Birch, to the science of archeology, and to Joseph Thomas Cunningham, in recognition of his services to zoological science and economic zoology. A pension of £50 is given to Mrs. Emily Rambaut, in recognition of the services rendered by her husband, the late Dr. A. A. Rambaut, to astronomical science.

A monument, consisting of a bas-relief by the

sculptor R. Bénard, in honor of the 500 French doctors and medical students who lost their lives during the war, was unveiled on June 14, at the Paris Faculty of Medicine, in the presence of the president of the French Republic, the dean of the Faculty of Medicine and a large and distinguished audience.

DR. J. CROSBY CHAPMAN, professor of educational psychology at Yale University, was drowned on July 15. Dr. Chapman was thirty-six years old.

DR. B. E. MOORE, professor of physics at the University of Nebraska, died on July 15, aged fifty-nine years.

DR. ALBERT JOHN OCHSNER, the well-known surgeon of Chicago, a former president of the American College of Surgeons, died on July 25, aged sixty-seven years.

DR. LUCIUS ELMER SAYRE, since 1891 dean of the school of pharmacy of the University of Kansas, died on June 20, aged seventy-eight years.

THE death is announced of Charles W. Eaton, of Haverhill, Mass., from 1884 to 1890 professor of civil engineering at the Massachusetts Institute of Technology. Mr. Eaton was later in private practice, his most important works being the construction of San Juan Harbor, Porto Rico, and the dredging of Mobile Bay.

THE death is announced at the age of seventy-six years of Dr. Felix Klein, professor of mathematics at Göttingen and editor of the *Mathematische Annalen*.

PROFESSOR GUSTAV MULLER, formerly director of the Astrophysical Observatory of Potsdam, died at Berlin on July 9 at the age of seventy-five years.

THE U. S. Civil Service Commission has announced the following open competitive examinations: Medical officer of various grades from junior to senior, to fill vacancies in all branches of the service, at entrance salaries ranging from $1,860 to $5,200 a year; Nautical assistant in the hydrographic office of the Navy Department, at an entrance salary from $1,320 to $1,680 a year; specialist in cotton classing, Bureau of Agricultural Economics, Department of Agriculture, at an entrance salary of $3,800 a year, or higher; junior meteorologist, Weather Bureau, at an entrance salary of $1,860 a year; biometrician, Bureau of Dairying, Department of Agriculture, at $3,800 a year; veterinarian and physiologist, Bureau of Dairying, Department of Agriculture, at an entrance salary of $3,800 a year. Full information and application blanks may be obtained at the office of the Civil Service Commission, 1724 F St., Washington, D. C.

DR. A. L. BAKKE, acting secretary, writes that the first summer meeting of the American Society of Plant Physiologists was held with the American Society of Agronomy at East Lansing, Michigan, on July 10 and 11. The first day was spent with the agronomists while the second was given over to a program of invitation papers and a business session. Professor Charles A. Shull, of the University of Chicago, called the meeting together and presented the new president, Dr. R. P. Hibbard, of Michigan State College. Dr. Burton E. Livingston, of the Johns Hopkins University, is vice-president, and Dr. Wright A. Gardner, of the Alabama Polytechnic Institute, continues as secretary. The attendance and the interest shown in the program were very good.

AT a recent meeting of the executive committee of the Highway Research Board of the National Research Council it was decided to hold the fifth annual meeting of the board at Washington, D. C., on December 3 and 4. Reports on progress received from the chairmen of the research committees show that they are conducting important studies on almost every phase of highway development, including finance, design, construction and maintenance, thus assuring a successful annual meeting. The program for the fifth annual meeting is now being prepared and will soon be announced.

IT is planned to hold in Rome an International Forestry Congress under the auspices of the International Institute of Agriculture, the Italian government and the American Tree Association. Mr. Charles Lathrop Pack, of the Tree Association, is a member of the committee of arrangements.

THE Swiss Society of Natural History will hold its hundred and sixth annual meeting, under the presidency of Dr. P. Steinmann, in Aarau from August 8 to 12. The conference meets in three sections—mathematics, physics, chemistry, mineralogy, petrography; geology, geophysics, meteorology, petrography; and medical biology, the history of medicine and science, botany, zoology, including entomology, anthropology and ethnology.

TERMS of the John Horsley Memorial Prize in surgery have been announced by the University of Virginia. This prize was established by Dr. J. Shelton Horsley, of Richmond, Va., a distinguished alumnus of the university, as a memorial to his father, and consists of two years' interest on $10,000, presumably $1,000, to be awarded every two years by a committee of the medical faculty of the university for a thesis upon some subject in general surgery. All graduates of the medical department of the University of Virginia, of not more than fifteen years' standing, are eligible for this prize. The prize is to be awarded

biennially at the final exercises of the university, beginning in June, 1927, by a committee consisting of the dean of the medical school and the professors of pathology, physiology, biochemistry, histology, embryology and surgery.

TRUSTEES of the estate of the late Sir William Dunn have allotted $10,000 a year for five years for cancer research, which has been assigned to the extension of experiments with filtrable viruses following the recent discovery of Dr. William E. Gye and Dr. J. E. Barnard. The British Medical Association, heard Dr. Gye's report on his cancer discovery and the subsequent debate behind closed doors.

UNIVERSITY AND EDUCATIONAL NOTES

THE University of Pennsylvania has plans in preparation for the erection of a new laboratory for physiological chemistry to cost about $1,000,000, with equipment. The work will be carried out in connection with an extensive building program at the institution, including an anatomical laboratory, for which foundations are being laid, to cost approximately $1,300,000.

THE board of administrators of the Tulane University of Louisiana has decided to reorganize completely the Graduate School of Medicine. A committee has been appointed to work out the plans of reorganization, and it is expected that the school will be fully organized and ready for work by the beginning of the 1925–1926 college year.

DR. JOHN J. KEEGAN, a member of the faculty of the College of Medicine of the University of Nebraska, at Omaha, has been appointed dean of the college to succeed Dr. Irving S. Cutter, who recently accepted appointment as dean of the Medical School of Northwestern University.

AT the University of California the professorial title of Dr. C. B. Lipman has been changed from professor of plant nutrition to professor of plant physiology and dean of the graduate division.

DR. A. G. WORTHING, for fifteen years a physicist at the Nela Research Laboratory, has become professor of physics in the University of Pittsburgh and head of the department, succeeding Dr. L. P. Sieg, dean of the college. Dr. Sieg retains a professorship in the department.

THE National Research Council announces the following appointments of holders of fellowships under the council: Dr. (Minnie) Jane Sands (M.D., Woman's Medical College of Pennsylvania), who has been studying since October, 1923, at the Royal Infirmary, Edinburgh, Cambridge, England, and at Western Reserve University, Cleveland, professor of physiology at the Woman's College of Medicine, Philadelphia. Dr. Clifford S. Leonard, Ph.D. (Wisconsin), since October, 1923, at Yale University, instructor in pharmacology at Yale University. Homer W. Smith, D.Sc. (Johns Hopkins), who for the past two years has been working at the Harvard Medical School, acting professor of physiology at the University of Virginia. Dr. Louis N. Katz, M.D. (Western Reserve), who has been studying at the University of London since August, 1924, senior instructor in physiology in Western Reserve University.

MAYNARD F. JORDAN, instructor of astronomy in Harvard University, has been appointed associate professor of astronomy at the University of Maine.

DR. ALFRED P. LOTHROP, professor of chemistry at Queen's University, Ontario, has been appointed associate professor of chemistry at Oberlin College.

DR. T. F. WALL has been appointed head of the department of electrical engineering in the University of Sheffield.

DISCUSSION AND CORRESPONDENCE

THE SIZE OF SEA WAVES

A PHOTOGRAPH of a large sea wave was published in the New York *Times* of December 7, 1924. This picture so impressively indicated the enormous size of the wave that the writer made special inquiries to establish the authenticity of the picture, realizing that the wave shown was far out of the ordinary even in great storms. The photograph was taken from on board the S. S. *Leviathan* and shows a wave advancing upon the bow of the ship and towering high above it. The top of the wave appears to be higher than the position of the camera. A special request brought the following letter:

I have made an exhaustive inquiry concerning the making of this photograph which was published in the New York *Times* of December 7. I hope that the information I am able to give you will prove of some value.

The photographer made this picture from "B" deck of the *Leviathan,* 60 feet above the waterline of the vessel and 224 feet from the bow. He informs me that at the moment the exposure was made the *Leviathan's* bow was in the trough of the wave and that he shot down at an angle to get the picture, the wave breaking immediately after the exposure was made. The photographer is not sure of the day on which the picture was taken, but he believes it to be Thanksgiving Day or the day following. At that time the *Leviathan* was encountering full gales,

reported at approximately 100 miles an hour. The ship was headed west and into the wind.

I understand in talking with officers that during this part of the storm one wave would be leaving the *Leviathan's* stern, another would be under her amidships and she would be entering on a third.

The *Leviathan* is 950 feet long.

From this you may be able to figure the length of the waves or their height.

Very truly yours,

DAVID A. BURKE,
Assistant General Manager,
United States Lines

On November 28, Thanksgiving Day, the S. S. *Leviathan* was about 1,300 miles (nautical) from Cherbourg and about 1,000 miles from American shores; on the following day she was about 300 miles nearer land. Long ago Stevenson pronounced a formula connecting the maximum height of waves with the "fetch" of the wind in deep water for distances from shore between 100 and 1,000 miles. The formula is as follows: $H = 1.5\sqrt{f}$. "H" is height of wave and "f" is the fetch of the wind. On November 28 the fetch of the wind was 1,000 miles, and on the next day it was 700 miles. Of course we have no assurance that the wind blew actually over the whole fetch from the mainland to sea, but on that supposition on November 28 the waves might have been 50 feet high and on the 29th 40 feet high. It happens that on the 27th the wind was from the north, which caused waves rushing transverse to the great storm waves here considered and which persisted in spite of the new series of waves. Consequently there were probably peaks and troughs upon the main waves which might well increase their height 10 or 15 feet.[1] As a result of these considerations the waves may have been as great as 60 feet in height from trough to crest, although it is generally agreed that in the North Atlantic Ocean forty-foot waves are of extreme size. Another line of attack arises from the length of the waves. According to the ship's officers these waves were commonly 475 feet long. Judging from critical reports of other storms it is likely that some waves were over 600 feet long. Waves of such a size are between 35 and 45 feet high irrespective of cross waves or breaking peaks. If the wave peak was actually as high above the trough as the camera when the photograph was taken the wave must have been considerably over 60 feet high, because although the camera was pointed down from the 60 foot elevation above the ship's water-line it was considerably more than 60 feet above the bottom of the trough of the wave.

From another of Stevenson's formulae the velocity of the wave may be computed. Although waves commonly run almost as fast as the wind which makes them, the extreme speed of the wind, 100 miles per hour, caused a departure from this common rule. The velocity of the wave is related to its length as follows: $V = \sqrt{5.123L}$.

Putting the value of 475 feet for "L" the velocity of the waves becomes 50 miles per hour.

It is a significant commentary on modern naval architecture and marine operation that the S. S. *Leviathan* was able to advance 300 miles in twenty-four hours, steaming against a wind of 100 miles per hour and plowing against waves which were running on an average 475 feet long and 40 feet high with a velocity of 50 miles per hour.

An examination of the evidence available indicates that this was one of the most violent storms ever recorded on the North Atlantic Ocean as far as size of waves is concerned.

T. T. QUIRKE
UNIVERSITY OF ILLINOIS

[1] Wm. Scoresby, British Association for the Advancement of Science, 1850.

HEARING BETTER IN THE PRESENCE OF A NOISE

Do certain hard-of-hearing persons hear better in the presence of a noise? Much has been spoken and published supporting the affirmative and negative answers to this question.[1] Yet, for some reason, no one has answered this question definitely and adequately on the basis of experimentation. Otologists, physicians and many other people, including those who have hearing impairments of a fixative type—usually called otosclerosis—quite generally have believed that otosclerotic hard-of-hearing people actually do hear better in the presence of a noise. Some very scholarly otologists have attempted to explain this phenomenon by supposing that the gross vibrations of the noise act upon the ossicular chain in such a manner as to set it into vibration, which makes this conductive mechanism of the middle ear a more efficient vehicle for transmitting speech or music to the internal ear. The noise, they claim, is supposed to increase the sensitiveness of the ossicular chain in much the same way that tapping or jarring the old form of "coherer," used for the detection of radio waves, increased its sensitiveness.

Kranz[2] and Fletcher[3] recently have advocated that these hard-of-hearing people actually do not hear better in the presence of the noise, but that the noise

[1] Three notes regarding this question have appeared in SCIENCE during the past six months: G. W. Boot, Oct. 17, 1924; F. W. Kranz, Dec. 12, 1924; B——, March 6, 1925. See also H. Burger, "De la Paracousie de Willis," *Rev. de laryngol d'Otol. et de Rhinol.*, 38: 561, 1917.

[2] F. R. Kranz, *Laryngoscope*, March, 1924.

[3] H. Fletcher, *Volta Review*, September, 1924.

is less of a disturbing factor to the hard-of-hearing people than it is to normally hearing people, and, therefore, they enjoy a relative advantage for hearing in the presence of a noise.

In an attempt to answer this question definitely and completely, the writer, in cooperation with Dr. I. H. Jones, has conducted some experiments. These experiments indicate quite conclusively that in the presence of a noise, otosclerotic hard-of-hearing persons sometimes *do hear conversation better than persons with normal hearing,* but that these same hard-of-hearing persons *hear conversation less well in the presence of a noise than they do in the quiet.*

First experiment: An otosclerotic hard-of-hearing person, having 40 per cent. of normal hearing for low-pitched tones and 60 per cent. of normal hearing for high-pitched tones, a person with normal hearing and the writer went into a large, reverberant concrete garage. The motor of a large automobile was set running at a very high speed, and the "cut-out" was opened, so that a very loud disturbing noise resulted. The hard-of-hearing person and the person with normal hearing were placed at equal distances from the writer, and the latter gradually raised his voice until he could be heard by one of the listeners. The hard-of-hearing person actually could hear the conversation slightly better than his normally hearing companion.[4]

Second experiment: The same otosclerotic individual was then tested for his minimal threshold of audibility, for representative tones throughout the speech range, first in a quiet room and then with various amounts of noise in the room. Whenever the noise became loud enough to be heard by him it decreased his auditory acuity for tones of all pitch; that is, the tones had to be made louder before he could hear them. The louder the noise, the louder the tones had to become before they reached his minimal threshold. Similar tests, with the same results, have been conducted upon six other persons with marked fixative impairments of hearing.

Third experiment: Word articulation tests, similar to those employed by telephone engineers in testing the speech transmission efficiency of a telephone circuit, have been applied to three otosclerotic hard-of-hearing individuals, first in a quiet room, and then, using the same loudness of speech, in the presence of an interfering tone or noise. Tones of 128 d.v., 256 d.v., 512 d.v. and 1,024 d.v., at various levels of loudness, and typical noises at various levels of loudness, were conducted by means of a pair of head phones to the ears of the individuals under test. Any kind of an interfering tone or noise, in every instance, reduced the percentage word articulation. There was no evidence whatever to indicate that these individuals could hear better in the presence of any kind of tone or noise, but there was abundant evidence to indicate that they could not hear so well.

These three experiments, therefore, seem to offer a satisfactory answer to this much discussed question.[5]

Thus, the first experiment indicates that in a noise of sufficient intensity, an individual with a fixative hearing impairment can hear conversation as well as or better than an individual with normal hearing. But also, as the second and third experiments indicate, the person with impaired hearing actually hears either tones or speech less well in the presence of a noise than he does in a quiet place; that is, either tones or noises interfere with his ability to hear other tones or conversation, and they interfere qualitatively and quantitatively in the same manner that tones or noises interfere with normally hearing persons.

In a certain sense, these two conclusions may seem contradictory, but the following facts, which include those advanced by Fletcher and Kranz, offer a satisfactory explanation of the two conclusions:

(1) A fixative type of hearing impairment is characterized by a much greater loss of acuity for the low-pitched tones than for the high-pitched tones. Further, recent experiments have shown that low-pitched tones produce a greater interfering effect upon speech than do high-pitched tones.[6] Therefore, the individual with this type of impairment is relatively "deaf" to those frequencies of the noise which produce the most damaging interfering effect.

(2) Again, since the individual with a fixative impairment has greater acuity for the high-pitched tones than for the low-pitched tones, and since good hearing for the higher tones—above 500 d.v.—is more important for the hearing of speech than good hearing for the lower tones, the individual with this type of impairment has relatively good hearing for those frequencies which are most important for the hearing of speech.

(3) In a noise, the loudness of conversation is in-

[4] Since this article was written similar qualitative tests have been conducted upon three other otosclerotic persons. These tests indicated that these hard-of-hearing persons, in the presence of a very loud noise, heard conversation approximately as well as, but no better than, persons with normal hearing.

[5] A more complete account of these experiments, including a larger series of patients tested, with quantitative data, will be published at a future date in an appropriate journal.

[6] Knudsen, "The interfering effect upon speech of tones and noises," *Physical Review*, about July, 1925. Paper read before American Physical Society, Pasadena meeting, March 7, 1925.

creased. The loud conversation, and also the loud noise, actuate the cochlea of the normally hearing individuals with much greater intensity than they do the cochlea of the individual with a conductive impairment. Therefore, because of the non-linear response of the ear, the cochlea of the normally hearing individual will be overloaded and hence will suffer both a relatively greater interfering effect from the noise and also a greater distortion of the speech than will the person with a conductive impairment.

There is another factor, which, though irrelevant to the experiments and conclusions described in this communication, contributes immensely to the advantage enjoyed by a person with a conductive impairment when he converses in the presence of a noise with a person with normal hearing. The normally hearing individual hears the noise with its full intensity, and therefore will increase the loudness of his voice relatively more than will the individual with a conductive impairment, who hears the noise with greatly diminished intensity. This also is the reason why, in a noise, it is difficult for a person with normal hearing to hear the conversation of a person who has a conductive hearing impairment.

In contrast to those who have conductive hearing impairments, persons with perceptive impairments claim they hear less well in the presence of a noise than in the quiet. Many observations upon individuals having perceptive impairments confirm this claim.

It is well established that individuals with nerve deafness suffer a much greater loss of acuity for the high-pitched tones than for the low-pitched tones. Further, the defect is one of the end organ and not of the transmitting mechanism. These two facts, together with the contrary of the facts stated in "1" and "2," explain why this type of "deaf" person does not derive the benefit from a noise that the person does who has a conductive impairment.

VERN O. KNUDSEN

DEPARTMENT OF PHYSICS,
UNIVERSITY OF CALIFORNIA,
SOUTHERN BRANCH

THE BARRO COLORADO ISLAND LABORATORY

MANY biologists and other scientists probably do not yet realize how easy and safe it now is to visit a new tropical world in Panama. To one like the writer, whose experience had been limited to the temperate zone, it is a revelation to observe what nature can do under constant summer temperatures and ample rainfall in the torrid zone. The vague qualms one may feel about fevers, dangers, snakes, insects and the heat are found to be largely unfounded when he reaches the Canal Zone; he finds that he may comfortably and safely wander along the jungle trails of the island. While my own interest in visiting the Isthmus was especially the fungi, I found upon arrival that, abundant though the fungi were, there was an even greater interest and value in observing the broader phases of plant and animal life. Incidentally, there are also the canal, the quaint cities and country and many other excellent reasons which make the trip profitable as well as pleasant. The National Research Council, Dr. Barbour, of the Museum of Comparative Zoology, Cambridge, Mass., and Mr. Zetek, the resident custodian, deserve the thanks of all of us for the opportunity they have provided.

G. R. BISBY

UNIVERSITY OF MANITOBA
WINNIPEG, CANADA

EVOLUTION AND THE BIBLE

THERE have recently been held in several of our Pacific Coast cities debates between the Reverend W. B. Riley and E. A. Cantrell on the question of evolution *versus* the Bible. The evolution side of these debates has been argued by Mr. Cantrell, who, according to press reports, is a representative of "The Science League." The public and press seems to be of the opinion that said Science League is a part of the American Association for the Advancement of Science or has some connection with it, though this is not the case.

In the above-mentioned debates, according to press reports, Mr. Cantrell attempts to reconcile the tenets of the Bible with the fundamental principles of science. He naturally fails to make a case and at the close of these debates a vote is taken with a result of about five to one in favor of the anti-evolution side.

As a member of the American Association for the Advancement of Science I wish to protest against such methods. The cause of science is in deplorable straits when it must be defended by such so-called scientists who would attempt to reconcile it with primitive Jewish folk lore.

Nothing has happened in a decade (in half a dozen decades) calculated to harm the cause of science more than the equivocal position of certain scientists of high station, who state that there is no conflict between science and religion (meaning, of course, the Jewish-Christian religion). Their stand in this regard has been followed by various publicists equally devoid of moral courage.

IRA D. CARDIFF

YAKIMA, WASHINGTON

QUOTATIONS

FRONT PAGE SCIENCE[1]

"BLACK RAYS" OF SUN JOLT THEORY OF GRAVITATION

MINNEAPOLIS ENGINEER'S DISCOVERY OF PUSHING, NOT PULLING, FORCE PUZZLES SCIENTISTS

Special Telegram to Public Ledger

MINNEAPOLIS, July 19.—H. J. Smith, an engineer, has physicists here in a quandary and admitting there may be a joker in the Newton theory regarding the forces that keep the earth in its orbit. The quandary is the result of positive demonstrations with what Mr. Smith has termed the hitherto undiscovered "black rays" of the sun.

Science has held that the sun exerts a pulling power on the earth and that this, with centrifugal force, has kept terra firma in its place. Smith set up a delicately constructed weighing instrument with a dial and pointer. The pointer indicated the full rays of the sun seemed to exert a pushing instead of a pulling effect.

Smith called in Dr. Henry A. Erikson, head of the physics department, University of Minnesota, and other scientists, and they could hardly believe their eyes as they saw the mysterious force exert a greater pushing power than ever.

Dr. Erikson at once canceled plans for a vacation and to-day was locked up in his laboratory constructing one of the Smith "attractometers" for a series of experiments. He refuses to give out a statement, but admitted frankly that he can not explain what he has seen and that, if the sun actually is exerting a pushing force on the earth, science has its work cut out to form a theory to take the place of or to at least supplement the Newtonian theory of gravitation.

DEVIL'S GRIP GERM BELIEVED DETECTED

PHILADELPHIA DOCTOR DECLARES MALARIA-LIKE PARASITE IS CARRIED BY MOSQUITOES

QUININE BEST REMEDY YET

DR. JAMES C. SMALL, bacteriologist of the Philadelphia General Hospital, has found what he believes to be the cause of Devil's grip, a disease similar to malaria.

The finding can not be affirmed definitely until more patients suffering with the disease are examined.

Devil's grip, Dr. Small explained, has nothing to do with influenza or la grippe. It is a contagious disease, which causes victims much pain in the chest and the lower ribs. Last year there was an epidemic of the fever in Philadelphia and examinations by Dr. Small disclosed that in each of the cases there were parasites in the blood. These parasites may be caused by mosquito bites or bites of other insects, Dr. Small said.

Parasites are a low form of life which burrow their way into the red blood corpuscles. As one of them grows larger it destroys the corpuscles and other parasites are created.

In his examination of blood specimens of persons affected by the disease, Dr. Small found the parasites were not frequent in the system.

Under a microscope he examined thousands of red blood corpuscles and found parasites in only a few instances.

The disease is not fatal, but causes the victim a great deal of pain for a week or more. The pains first develop in the chest and come on very suddenly. The patient has a high fever for a day. The pains and fever will subside in most cases and then return in four days. Headaches occur constantly and backaches occasionally.

Dr. Small said it had been found that quinine is the best remedy for the pains and fever.

The only case reported this summer was in Huntington, Va., the physician said. An epidemic may occur in Philadelphia later in the summer, he said, but aside from possibility of proving his preliminary findings, he does not feel any great progress can be made toward stopping the disease.

No reason has been found for the pains entering in the region of the chest. The entire blood system is affected, he explained, and for that reason it is strange the pain should be local. X-ray examination of the lungs and chest show no abnormal condition.

[1] From the Philadelphia *Public Ledger* of July 20.

SCIENTIFIC BOOKS

Einführung in Die Allgemeine Kohlenpetrographie. By ROBERT POTONIÉ. Gebruder Borntraeger, Berlin, 1924.

THE present volume will excite probably some surprise among mineralogists and petrographers, since it is written from the botanical standpoint. It marks, however, a tendency which is growing at the present time. The actual study of coal shows that it is a botanical product, and as such can naturally be best treated from the botanical standpoint. The geologists and chemists have in the past not been able to throw a great deal of light on the subject of coal and the present author emphasizes the importance of the botanical viewpoint. He is the son of the late Henry Potonié, who is well known as the author of many and important contributions to the study of coal. The book is distinguished by the large amount of attention which is given to the actual structure of coal, a subject which has been, for obvious reasons, much neglected in the past. The investigations carried on in America have largely obliterated our previous igno-

rance of the structure of coal and the researches of Thiessen, Turner and the reviewer have made clear what was previously a dark subject. The writer has made full use of the American work on coal and his treatment is most appreciative.

The work is divided under a number of headings, namely, "Classifications of coals," "The macroscopic structure of coal and its origin," "The microscopic structure of coal and its origin," "The petrographic constituents of coal," and "The participation of the various substances of the plant and animal body in their organization." The volume contains 271 pages and 80 illustrations, the most of the latter original or from very recent sources. A particularly commendable feature is a large amount of attention given to the micro-chemistry of coal, a subject which the author has made particularly his own and which is of great importance. Naturally, his father's views are treated at considerable length and with respect, but the author nevertheless shows a highly commendable open-mindedness on many subjects. This book will be indispensable to all geologists, chemists and botanists who are interested in the subject of coal.

E. C. JEFFREY

HARVARD UNIVERSITY

Out of the Valley of the Forgotten, or From Trinil to New York. By JOHN EDMISTON BAUMAN, head of the Biology Department, Augustana College, Sioux Falls, South Dakota. Two volumes. Published by the author.

A MOST unique work is Bauman's "Valley of the Forgotten," which may be briefly described as an encyclopedia of deductions from evolution.

The poetic title is thus explained by the author:

> It is intended among other things to show that in the forgotten days of man's early evolution, he went grievously astray in his ideas, falling into progress—and initiative—stupefying superstitions on the one hand and into many irrational ways of looking at the universe in general, and into a not only utterly irrational, but debasing and brutalizing notion of intimate sexual concerns, being shameful and indecent, on the other.

Accepting the known and rationally implied facts of orderly change, termed evolution, which he gives with much care and general accuracy, Professor Bauman sets out to show the relation of evolution to human conduct in all its varied phases. In this he shows broad reading and good judgment, though somewhat disposed to "lay down the law" in disputed questions. He repudiates "fundamentalism," with all its cumbersome traditions, while insisting on his right to be a Christian. He argues for "immortality" on scientific data as well as for the "existence of God." He has much to offer on sex problems, not all of it likely to be generally accepted. His discussions range from the regulation of restaurants, the use of proper nasal sprays and the sins of St. Augustine to bacteria, wicked and benign, to woman's dress, to the abolition of war and to the purification of religious belief. Amidst very much that is true and wise, and as varied as human interests, we stumble on one sentence: "The whole drift of human evolution would be a meaningless and sinister affair if there were to be no future existence."

> I ask for nothing; let the balance fall,
> All that I am or know or may confess
> Swells but the weight of mine Indebtedness!

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

THE PREPARATION OF PROTOZOA FOR CLASS USE

THE rapidity of movement of protozoa makes their study a matter of great difficulty for the beginner, particularly if he is getting acquainted with the use of the microscope at the same time. Identification and careful study likewise are rendered equally trying for the more experienced student. The time-honored method of partially immobilizing the organisms in a viscous medium such as a gum solution or by means of cotton fibers is of great assistance and has the advantage of permitting a study of the living organism. The use of the surface tension, as developed by the microdissectionists, is not feasible for class use unless perhaps as a means of demonstration.

Attention is called to the following method because of the rapidity with which the common protozoa and algae may be prepared for class use. The method is not by any means new, but does not appear to have received the attention it deserves. The material is collected from the aquaria or other source of protozoans by means of a pipette and placed in a centrifuge tube. A hand centrifuge will throw down the organisms within a minute at most, and immediately after the removal of the tube from the centrifuge the greater portion of the superlatent water is pipetted off. A few drops of 1 per cent. osmic acid solution are added so that the resulting solution of osmic acid is about one half per cent. Two cubic centimeters of such a strength of osmic acid will fix a cubic centimeter of precipitated organisms, so that the expense of the reagent is negligible. A few drops of distilled water are added and the material is ready for class use. For continued study a glycerine solution is better. The common fresh water protozoa—

amoebae, ciliates and flagellates—when so prepared can scarcely be distinguished from living material except for the absence of movement. Chloroplasts such as those found in Euglena and the algae retain their green color, and with a nearly closed condenser the finer details, particularly of the cilia or flagella, are shown very clearly.

If permanent mounts are desired the usual staining methods may be applied, the various reagents being added to the material in the centrifuge tube. Iron haematoxylin gives splendid results after fixation with osmic acid, and with the exception of the destaining process with iron alum, the material need not be removed from the tube until it is in xylol. Chloroplasts do not seem to be affected by the various reagents, and material in balsam will remain green for weeks, after which the chloroplasts slowly fade. For finer details in such organisms it is better to bleach the chloroplasts with potassium permanganate, 1 per cent., and oxalic acid, 5 per cent., for about five minutes each before staining. Fixation in the osmic acid should be for from thirty minutes to an hour if permanent preparations are desired. This fixation, being cytoplasmic, offers an enlightening contrast to the more customary Schaudinn's fluid.

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SPECIAL ARTICLES

THE RELATION BETWEEN PROPERTIES AND CHEMICAL COMPOSITION OF SOIL COLLOIDS

IN previous publications of the Bureau of Soils it has been shown that the colloidal materials extracted from different soils may vary widely in adsorptive capacity, in heat of wetting and in chemical composition. During the past two years a series of different colloidal soil materials has been investigated for many other properties, such as size of particles, swelling, viscosity, electrical behavior and exchange of bases. The data, which are being prepared for publication, show that the colloidal materials extracted from different soils vary with respect to these properties also.

It appears, as might be expected, that the various properties of the colloid are more or less related. A colloid, for instance, which undergoes a large volume change when wetted by water, usually shows a high heat of wetting and a high adsorptive capacity for ammonia gas.

The properties of different soil colloids appear also to be related to their chemical composition. The major constituents of the soil colloidal material are silica, alumina and iron, and, in the case of many colloids, the properties vary fairly regularly with the contents of these major constituents as expressed by the molecular ratio of silica to alumina plus iron.

An example of interrelationship between properties of the colloid and of parallelism between properties and chemical composition is shown in Table I. In this table a series of colloids extracted from different soils is arranged in ascending order of the ratio, silica to alumina plus iron. The heat (in small calories) evolved by these colloids on immersion in water and the ammonia gas adsorbed are shown in columns 3 and 4. In order to make the relationship more apparent and to bring out individual exceptions, the data of columns 2, 3 and 4 are expressed relatively in columns 5, 6 and 7. The lowest value in each series of determinations is placed at zero and the highest value at 100. By this procedure the different orders of magnitude of the three series of data are equalized; also the amplitudes of variation between the lowest and highest determinations are brought to 100 in each series. Most of the data in the table are taken from previous publications of this Bureau.[1, 2, 3]

It is apparent that on the whole there is a close parallelism between the heats of wetting, ammonia adsorptions and the silica ratios of the different colloids. Coefficients of correlation[4] for these three series of values are as follows: heat of wetting with ammonia adsorption 0.99, heat of wetting with silica ratio 0.93 and ammonia adsorption with silica ratio 0.90. The high coefficients of correlation, together with the fact that correspondence between the lower relative values in columns 5, 6 and 7 is about as good as correspondence between the higher relative values, indicate that the three series of values are approximately straight line functions of one another.

The correlation between heat of wetting and ammonia adsorption may be expected to hold fairly well for practically all soil colloids. But the correlation between heat of wetting (or ammonia adsorption) and $\frac{SiO_2}{Al_2O_3 + Fe_2O_3}$ is probably subject to

[1] Anderson, M. S., "The heat of wetting of soil colloids," *Jour. Agr. Research*, 28: 927–935 (1924).

[2] Gile, P. L., *et al.*, "Estimation of colloidal material in soil by adsorption," U. S. Dept. Agr. Bul. 1193 (1924).

[3] Robinson, W. O., and Holmes, R. S., "The chemical composition of soil colloids," U. S. Dept. Agr. Bul. 1311 (1924).

[4] Calculated according to the formula given by Tolley, H. R., and Mendum, S. W. "A method of testing farm-management and cost-of-production data for validity of conclusions," U. S. Dept. Agr. Circular 307 (1924).

TABLE I

HEAT OF WETTING, AMMONIA ADSORPTION AND $\frac{SiO_2}{Al_2O_3 + Fe_2O_3}$ RATIO OF COLLOIDAL MATERIALS ISOLATED FROM DIFFERENT SOILS

Source of colloidal material	Molecular ratio $\frac{SiO_2}{Al_2O_3 + Fe_2O_3}$	Heat of wetting per gram of colloid	NH_3 adsorbed per gram of colloid	Relative values $\frac{SiO_2}{Al_2O_3 + Fe_2O_3}$	Relative values Heat of wetting	Relative values NH_3 adsorbed
		Calories	Grams			
Cecil subsoil	1.20	4.5	0.0192	0	0	3
Cecil soil	1.34	6.2	0.0230	7	13	12
Chester soil	1.77	7.2	0.0293	28	21	26
Norfolk subsoil	1.84	6.0	0.0295	32	11	27
Huntington soil	1.86	8.3	0.0319	33	29	32
Sassafras subsoil	1.89	9.8	0.0340	34	40	37
Hagerstown subsoil	1.89	7.9	0.0299	34	26	28
Susquehanna subsoil	1.98	5.3	0.0177	40	6	0
Miami subsoil	2.66	11.8	0.0358	72	56	41
Marshall soil	2.82	14.2	0.0536	80	74	82
Stockton soil	2.85	16.3	0.0617	81	90	100
Wabash soil	3.16	17.6	0.0614	97	100	99
Sharkey soil	3.23	16.3	0.0609	100	90	98

some marked exceptions. In the case of the Susquehanna subsoil colloid there is poor agreement between the heat of wetting and the silica ratio, although the agreement between heat of wetting and ammonia adsorption is very good. A correlation of the silica ratio with the heat of wetting or adsorption would not be expected to hold for colloids from peat soils, which are composed chiefly of organic matter and contain comparatively little silica, alumina and iron. Furthermore, colloids exceptionally low in silica and high in alumina and iron may as a class be exceptions to this correlation. For instance, a colloid containing only 15 per cent. of silica with a $\frac{SiO_2}{Al_2O_3 + Fe_2O_3}$ ratio of 0.55 has recently been isolated from a deep tropical subsoil. The heat of wetting of this sample is 8 calories, or approximately the magnitude usually given by colloids having a silica ratio of about 1.9.

The $\frac{SiO_2}{Al_2O_3 + Fe_2O_3}$ ratio is not the only expression of chemical composition that shows a parallelism to the properties of the colloid. It was pointed out in a recent bulletin of this Bureau[5] that the colloids high in silica were usually low in alumina, high in monovalent and divalent bases and low in combined water. A fairly good correlation obtained between the ratio, $\frac{SiO_2}{Al_2O_3 + Fe_2O_3}$, and the ratio $\frac{SiO_2}{CaO + Na_2O}$ for a series of soils. In view of these relationships, it follows that other chemical constituents beside the silica ratio correlate with the properties of the colloid. For instance, some properties appear to be closely related to the percentage of calcium or to the total exchangeable monovalent and divalent bases. Joseph and Hancock[6] have suggested that the properties of colloids from soils and clays probably bear a general relationship to the $\frac{SiO_2}{Al_2O_3}$ ratio, the more plastic clays having the higher ratios.

A knowledge of the interrelationships of the properties of soil colloids and of the correlation between chemical composition and properties is of practical value in supplying a basis for predicting the general behavior of the colloids without extensive physical tests or complete chemical analyses. Similar relationships between properties and chemical composition doubtless obtain for the colloidal materials of ceramic clays and the recognition of these relations should be important in the ceramic industries.

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CONTINUOUS REPRODUCTION OF MICRO-ORGANISMS IN SYNTHETIC MEDIA

THE controversies and work of Pasteur, von Liebig, Mayer and Nageli suggest that yeast may fail of

[5] Robinson, W. O., and Holmes, R. S., p. 16, *l. c.*

[6] Joseph, H. F., and Hancock, J. S., "The composition and properties of clay," Trans. Chem. Soc. 125: 1888–1895 (1924).

continuous cultivation in media affording an only source of nitrogen in ammonium salts. Growth and reproduction in a medium wholly synthetic has been generally considered impossible. Vitamine B or substances of the nature of "bios" are held necessary by various investigators for the continuous growth and reproduction of *Saccharomyces cerevisiae.*

Fulmer, Nelson and coworkers[1, 2, 3, 4] have reported continuous growth and reproduction in their medium E, composed of inorganic salts and cane sugar, and that yeast was subcultured when a synthetic product, methose, was substituted for cane sugar. Relatively large inoculations were used and single cell cultivation was not attempted. MacDonald and McCollum[5] question the dependence of yeast on vitamine B or substances of the nature of "bios."

In recent articles Robertson and Davis[6] and Robertson[7] conclude that yeast is incapable of synthesizing its own growth-stimulating substance or substances in their media, and that yeast cells to a large extent possess the power of "taking over" these essential food substances, and that growth in synthetic media is roughly proportional to the number of cells used for the original inoculation. They failed to obtain reproduction beyond the 12th or 15th generation (transfer). Willaman and Olsen[8] stress the possibility of retention by the sugar of unanalyzable traces of "bios." Williams[9] maintains that vitamine B is necessary for the continuous growth of yeast.

We have employed the medium E base of Fulmer and Nelson, Robertson and Davis medium and Nageli solution. Special emphasis was laid on the purity of the chemicals and cleanliness of the glassware and precautions taken to destroy any vitamine B that might be adsorbed. For energy sources we have employed synthetic methose and succinic acid and also distilled glycerol (280° C.) and 7-day hot 95 per cent. alcohol continuously extracted dextrose. Methose, first synthesized by Loew,[10] was prepared from formaldehyde by the catalytic action of lead, MgO and $MgSO_4$ using CO_2 and K_2HPO_4 to precipitate the salts.

Single cell cultivation was carried out in the following manner: Direct microscopic examination was made of nutrient silicic acid gel plates smeared with a culture that had grown in the liquid synthetic medium for several weeks; single cells were marked, and after growth, transfers were made into the liquid medium. Since then cultures have been transferred on the average every 2 or 3 days for longer than 5 months. The use of Nageli solution was abandoned in favor of medium E. Robertson and Davis medium in our hands has not afforded continuous reproduction of our cultures of *Saccharomyces cerevisiae* when used at 30° C.

Medium E base at 30° C. ± 1° and succinic acid, methose, glycerol or dextrose have afforded continuous growth and reproduction of the following pure cultures: 14 races of *Saccharomyces cerevisiae,* 1 *Torula rosea,* 1 *Torula liquefaciens,* 1 *Oospora lactis,* 1 *Saccharomyces ellipsoideus.* Two cultures of cerevisiae failed to adapt themselves and were lost. Aeration greatly assisted liquid culturing. Heretofore results, apparently, have depended upon the use of 1 race of *Saccharomyces cerevisiae,* or 1 species of yeast giving rise to discrepancies and to results not applicable to generalization.

The same four energy sources in a base of K_2HPO_4 2 gm, $MgSO_4$ 0.1 gm, Fe_2Cl_6 trace, $(NH_4)_2SO_4$ 2gm (omitted in growth of nitrogen-fixing bacteria), $CaCl_2$ 0.1 gm and water 1 liter, have been employed in a study of bacterial vitamine requirements. The following organisms, subcultured by using an inoculum equivalent to the amount of a straight needle transfer from liquid medium, have been continuously cultured in this liquid medium base, utilizing at least three of the four energy sources: *Escherichia coli, Aerobacter aerogenes, Proteus vulgaris, Pseudomonas fluorescens, Encapsulatus pfeifferi, Pseudomonas cyanogena, Bacillus megatherium, Bacillus mycoides, Bacillus subtilis, Serratia marcescens, Azotobacter chroococcum, Rhizobium leguminosarum.*

The essential presence of vitamine B or substances of the nature of "bios" in the medium for growth and reproduction of certain yeasts and bacteria, notably *Azotobacter chroococcum,* has not manifested itself in our work unless such substance or substances were synthesized during the synthesis of methose and succinic acid, two entirely different processes; and failed to be extracted from the dextrose and did distil over with the glycerol. It appears reasonable to conclude in the light of our present knowledge that certain yeasts, torulae and bacteria may be continuously cultured in a medium wholly synthetic and that no addition of vitamine B or substances of the nature of "bios" is necessary. If such substances are necessary for the growth and reproduction of these organisms, they are metabolized.

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1 *Jour. Am. Chem. Soc.*, 1921, *43*, p. 186.
2 *Jour. Biol. Chem.*, 1922, *51*, p. 77.
3 *Jour. Infect. Dis.*, 1923, *33*, p. 130.
4 *Jour. Biol. Chem.*, 1923, *57*, p. 397.
5 *Jour. Biol. Chem.*, 1921, *46*, p. 77.
6 *Jour. Infect. Dis.*, 1923, *32*, p. 153.
7 *Jour. Infect. Dis.*, 1924, *35*, p. 311.
8 *Jour. Biol. Chem.*, 1923, *55*, p. 815.
9 *Jour. Infect. Dis.*, 1919, *38*, p. 465.
10 *Ber. Chem. Ges.*, 1889, *22*, p. 470.